MRI

From basic to advanced

Ahmed Samir Ibrahim
Assistant Prof Radiodiagnosis Department - Ain Shams Univ - Egypt
Member of ESMRMB & RSNA

MRI

From basic to advanced

Intended Learning Outcomes (ILOs)

- Knowledge
- Skills
- Attitude

Quality Assurance Unit

Objectives

Part I: MRI Physics/Sequence

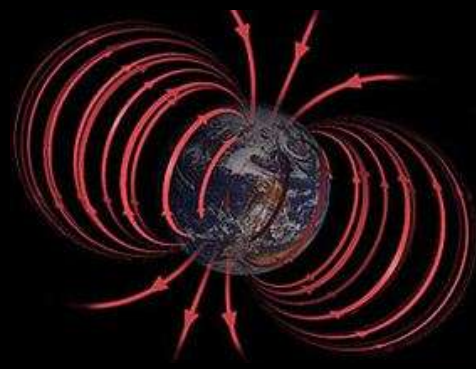
Part II: MRI Neuro + spine

Part III: MRI body + Msk

Part IV: MRI Msk + Cardiac

Part I
MRI
Physics / Sequences

Earth attraction is of: 0.3 - 0.7 Gauss



10.000 Gauss = 1 Tesla = 1 T

MRI machines = 0.2, 0.5, 1, 1.5, 3 and 8 T

MAGNETIC RESONANCE (MR) ENVIRONMENT SCREENING FORM FOR INDIVIDUALS*

WARNING:

IMPORTANT INSTRUCTIONS

Specific absorption rate (SAR):

Measurement used to describe absorption of RF energy,

Expressed in Watts / Kg

Max. rise (FDA) = < than 1°C

MRI safety in patients with cardiovascular devices

AHA scientific statement published in 2007, endorsed by ACC, recommended the following:

1. Coronary stents (in particular DES), prosthetic heart valves, annuloplasty rings, sternal wires, aortic graft stents except for Zenith AAA endovascular graft (Cook), many IVC filters and embolization coils are generally MRI safe
2. ICDs, permanent pacemakers, retained transvenous pacemakers or defibrillator wires and catheters that contain conductive wires like temporary pacing catheters, Swan-Ganz or thermodilution catheters are MRI unsafe
3. http://www.MRIsafety.com http://www.IMRSER.org

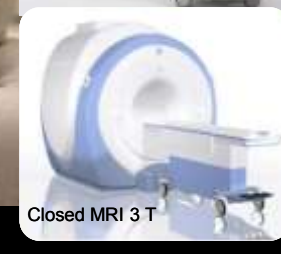
Open MRI 0.2-1 T

Closed MRI 1.5 T

+ Dynamic MRI

Extremity Open MRI 0.2 T

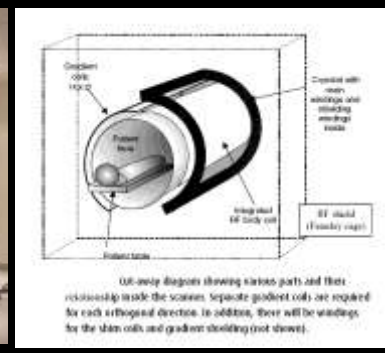
Open MRI 1 T



Closed MRI 3 T

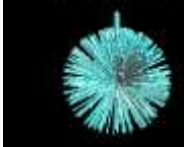
Clinical MR imaging unit "Magnet"

- Superconducting magnet: B_0 field
- Transmitting RF coil: B_1 field
- Receiving coil: surface / volume / phased-array coils
- Gradient coils: x-y-z spatial localization (from 20-45 mT/m)
- Computer: Fourier transform (FT)
- Shim coils
- Faraday's Cage



H^+ proton

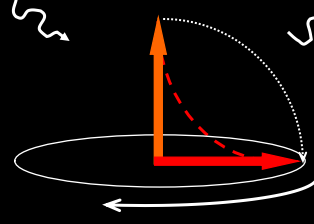
- Has a spin = high magnetic moment, their net output in body = zero
- Present in water & fat of body tissues (most abundant in body = best signal)
- Best image = High SI



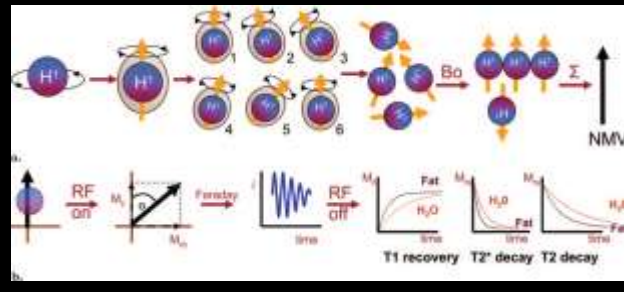
In MRI: Alignment of all H^+ in one direction

Signal to Noise = signal intensity (SI)

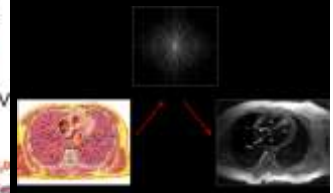
RF coil = Radio frequency = "E" to align all H^+ with exact same frequency against power of magnet



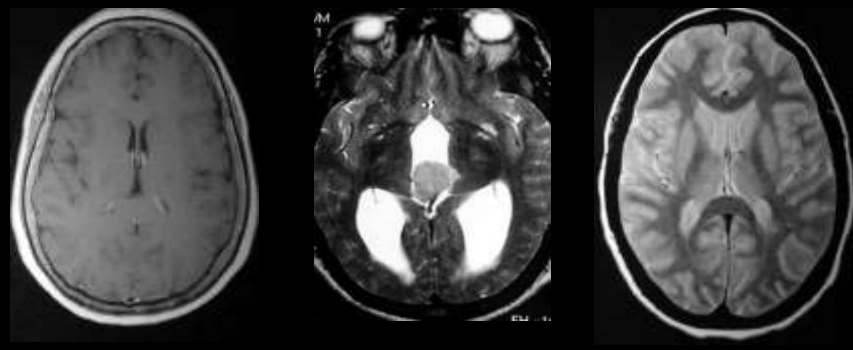
Resonance signal = S according to H^+:
1- Amount
2- Location
3- Timing = Time1, Time2



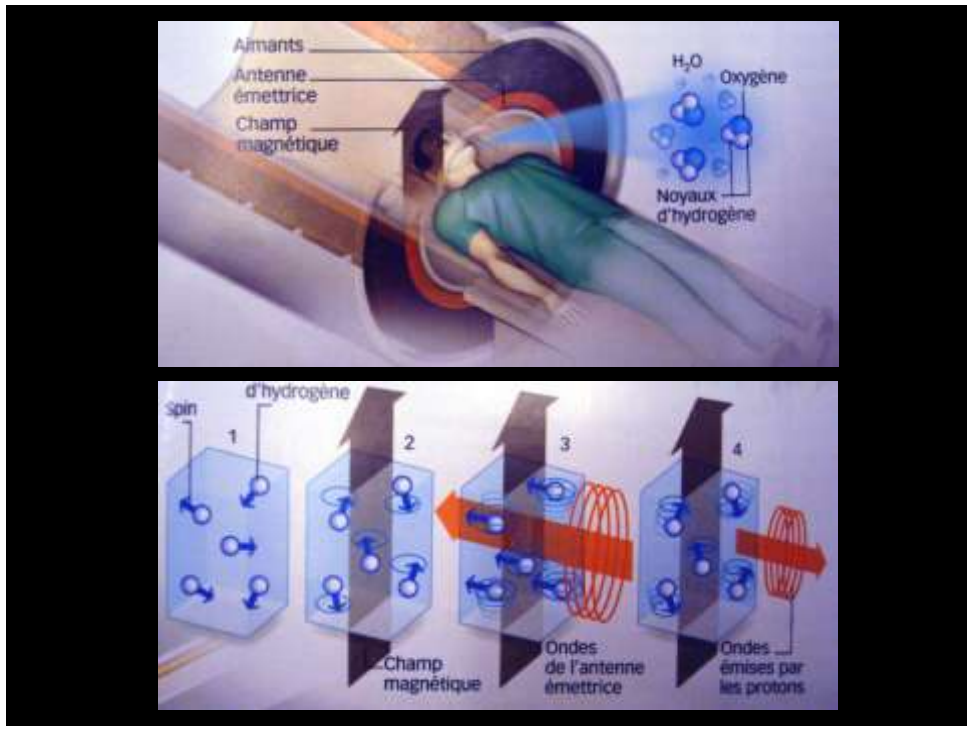
Fournier transformation

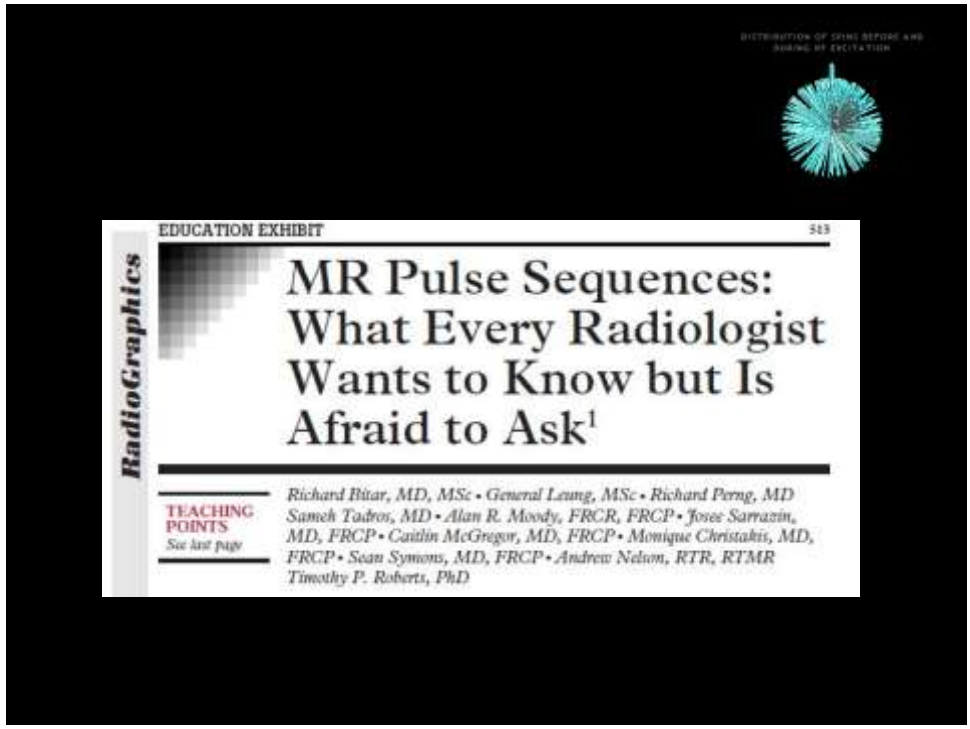


- T1w (↓TR - ↓TE) = *TR* 250–700 ms and TE 10–25 ms
- T2w (↑TR - ↑TE) = *TR > 2000 ms* and TE *> 60 ms*
- Proton Density = PD (↑TR - ↓TE)



Air / scar (no H^+)	Very dark	Very dark
Cortical bone (VEP)	Dark	Dark
Ligament / tendons	Dark	Dark
Calcifications	Dark	Dark
Fat (Dermoid, SC fat)		Dark
Bone marrow (yellow)		Intermediate
Protein		Intermediate
Fluid (CSF, ascitis, vitreous)	Dark	Bright
Heme = Acute blood	Intermediate	Intermediate
Heme = Subacute bl.	Bright	Bright


Aimants
Antenne émettrice
Champ magnétique
H_2O
Oxygène
Noyaux d'hydrogène
Spin
d'hydrogène
1
2
3
4
Champ magnétique
Ondes de l'antenne émettrice
Ondes émises par les protons

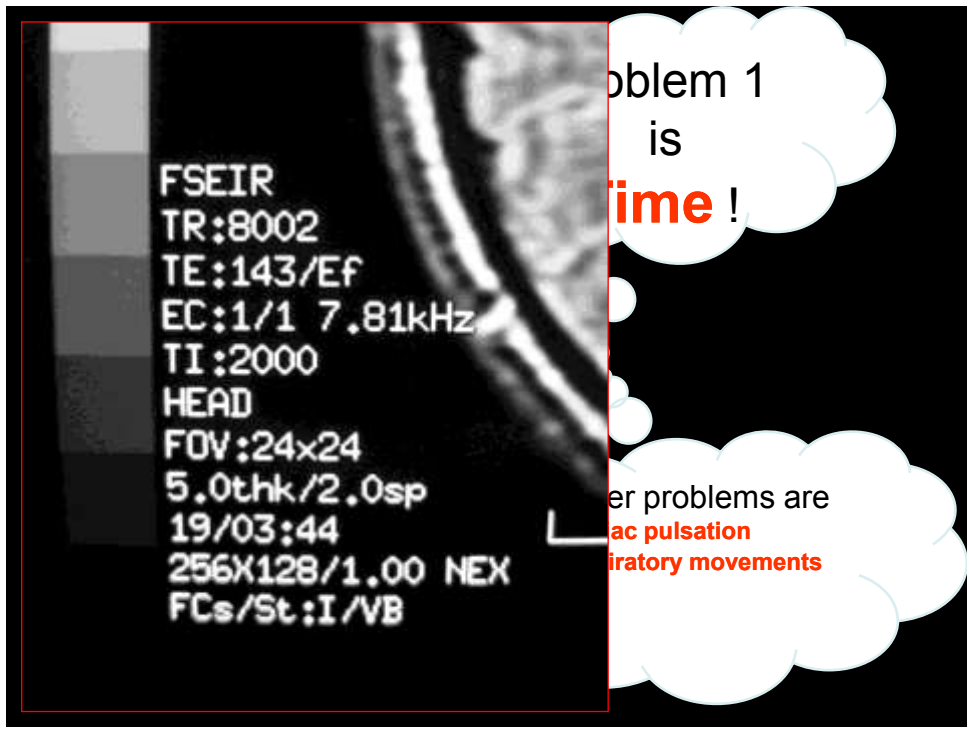

RadioGraphics
EDUCATION EXHIBIT
513
MR Pulse Sequences: What Every Radiologist Wants to Know but Is Afraid to Ask[1]
TEACHING POINTS
See last page
Richard Bitar, MD, MSc • General Leung, MSc • Richard Perng, MD
Sameh Tadros, MD • Alan R. Moody, FRCR, FRCP • Josee Sarrazin, MD, FRCP • Caitlin McGregor, MD, FRCP • Monique Christakis, MD, FRCP • Sean Symons, MD, FRCP • Andrew Nelson, RTR, RTMR
Timothy P. Roberts, PhD

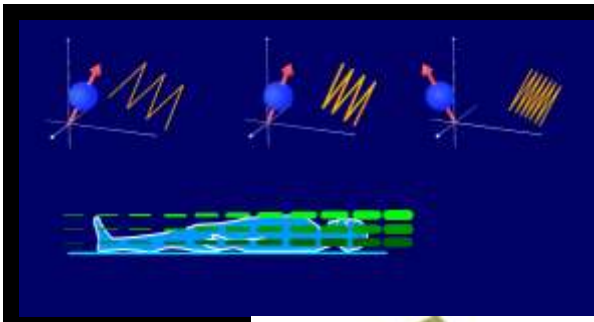
MR Acquisition time

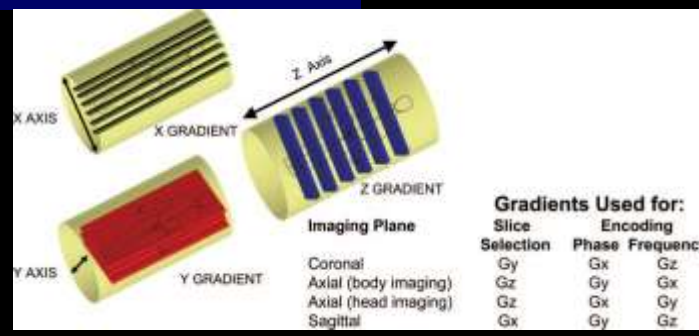
AT = TR x N x n

Repetition time	x	Nex	x	Matrices lines
2000 ms	x	2	x	256 x 256

17 min !!







How to select an MRI image ?

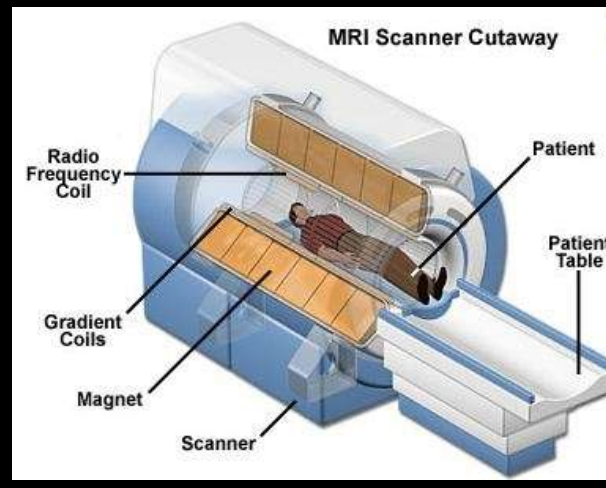
Superimpose a 2nd magnetic field = gradient Coil = gradient Field:

MRI coils

- **Volume coil** (surrounding extremity of body as head, knee, extremity coils)
- **Body coil** (2 pieces for abdomen = synergy body or torso GE)
- **Surface coils** (placed on/or close to body)
- **Phased array coils** (several small coils [elements] → HR imaging)



Clinical MR imaging unit "Magnet"



- Superconducting magnet: B_0 field
- Transmitting RF coil: B_1 field
- Receiving coil: surface / volume / phased-array coils
- Gradient coils: x-y-z spatial localization
- Computer: Fourier transform (FT)
- Shim coils + Faraday's Cage

MRI advantages :

1- Better contrast: tissue differentiation

2- Multi-planar, reconstruction…..capacities

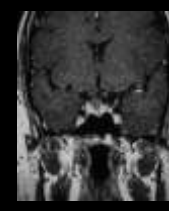
3- No X-ray exposition

4- New techs: MRS, MRA, fMRI, Diffusion, DTI…

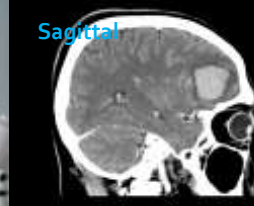
5- More info / examen

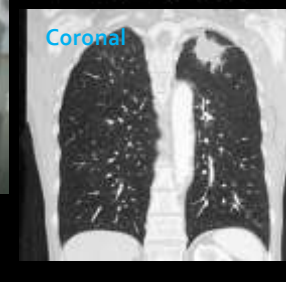

Axial


Sagittal

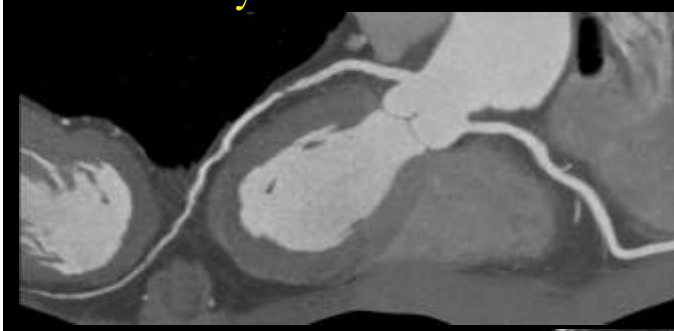

Coronal

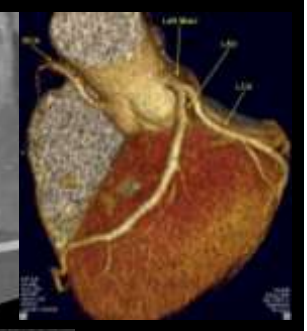
New MDCT generations…..

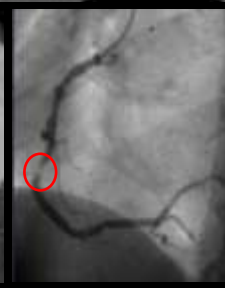




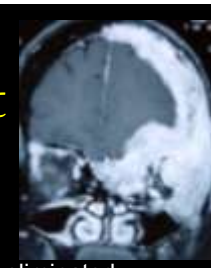
Coronary arteries: 2-5 mm !!







Exogenous MR contrast



1-**Paramagnetics** (T1 contrast agents):
- All GD-based contrasts are safe being low osmolar,
- HL is of 1.5-2 hrs, within 24 hrs 95% of CM will be renally eliminated
- In high dose, Gd will decrease SI on T2w images (seen in bladder for eg)
- Atomic number of Gd is 64 w compares favourably with that of x-ray CM iodine 53, so Gd enhances on CT

2-**Ferrromagnetics supermagnetic** (T2 contrast agents)
- SPIO (Super-magnetic Iron oxide)
- USPIO (Ultra-small super-Paramagnetic Iron oxide): has a S & Sp > 90% in detection of lymph node metastasis (high SI)
- MDP used in liver (absorbed via liver macrophages) thus suppressing normal liver and tumor is so better seen.

New: Fe oxide nanoparticle

Nephrogenic Systemic Fibrosis (NSF)-1

- **Kidney Dialysis & Renal Failure Patients at Highest Risk to MRI Contrast Dye with Gadolinium**
- Patients with kidney failure,kidney disease and/or renal failure are at the greatest risk of contracting a horrible fibrosing skin disease when they are given a gadolinium contrast dye used in MRI and MRA. Kidney failure patients and especially those on dialysis have kidneys that often have lost 20-90% kidney function or filtration rate. In these renal failure and kidney disease patients their slow or poorly functioning kidneys don't filter out the gadolinium contrast dye as quickly, whereby the MRI contrast dye stays in the body too long.
- The danger is the longer the contrast dye stays, the greater chance of the outside protective layer or coating has to break down inside the body. When the outside coating or chelate detaches or leaves the gadolinium, then the free gadolinium (a toxic metal) travels thoughout the body causing fibrosing or scar tissue in the skin, muscles joint, and internal organs resulting in NSF or NFD in some kidney failure patients.
- Though suspected for years, it was finally in 2007, Nephrogenic Systemic Fibrosis (NSF) that was linked to use of gadolinium based MRI contrast dye. Nephrogenic Systemic Fibrosis NSF symptoms may include patches of red skin, thick areas of skin, joint pain, muscle pain, yellow spots on eyes, blister like lesions, acne like pimples, hip and rib bone pain, renal & kidney failure, rib pain and hip bone pain. This rare fibrosing disease called Nephrogenic Systemic Fibrosis and Nephrogenic Fibrosing Dermopathy (NFD) can cause serious catastrophic disabling injuries to its victims.
- The cause of NFD and NSF are not fully understood, but it associated with exposure to gadolinium used in MRIs and MRAs with contrast dyes. information and NSF data. Nephrogenic Systemic Fibrosis (NSF) by definition occurs with some kidney or renal failure, however many have never undergone dialysis and others have received only peritoneal dialysis.

Gadopentetic acid
complex of gadolinium with DTPA
(*d*iethylene*t*riamine*p*enta*a*cetate)

Nephrogenic Systemic Fibrosis (NSF)-2

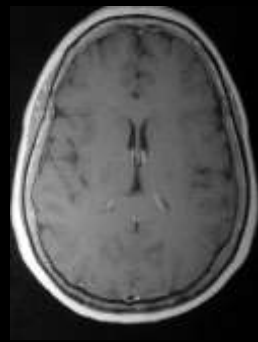
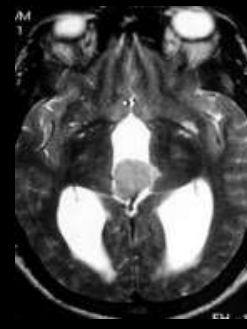
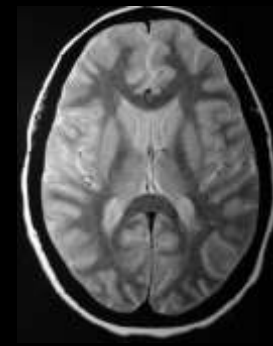
Table 3. Physical properties of gadolinium chelates and their association with NSF†

Brand name	Generic name	Acronym	Chemical structure	Charge	Cases of NSF
Omniscan‡	Gadodiamide	Gd-DTPA-BMA	Linear	Non-ionic	Yes
OptiMARK	Gadoversetamide	Gd-DTPA-BMEA	Linear	Non-ionic	Yes
Magnevist‡	Gadopentetate dimeglumine	Gd-DTPA	Linear	Ionic	Yes
MultiHance	Gadobenate dimeglumine	Gd-BOPTA	Linear	Ionic	No
Primovist‡	Gadoxetic acid disodium salt	Gd-EOB-DTPA	Linear	Ionic	No
Vasovist	Gadofosveset trisodium	Gd-DTPA	Linear	Ionic	No
ProHance‡	Gadoteridol	Gd-HP-DO3A	Cyclic	Non-ionic	No
Gadovist‡	Gadobutrol	Gd-BT-DO3A	Cyclic	Non-ionic	No
Dotarem‡	Gadoterate meglumine	Gd-DOTA	Cyclic	Ionic	No

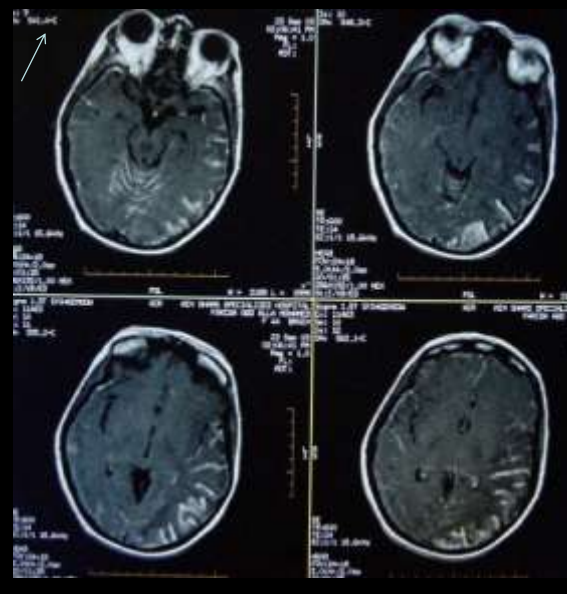
† Reproduced with permission from Idee *et al.*

‡ ‡Available in Australia. NSF, nephrogenic systemic fibrosis.

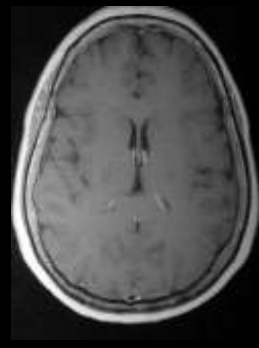
- T1w (↓TR - ↓TE) = *TR* 250–700 ms and TE 10–25 ms
- T2w (↑TR - ↑TE) = *TR > 2000 ms* and TE *> 60 ms*
- Proton Density = PD (↑TR - ↓TE)

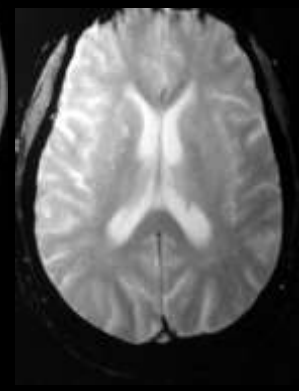
MRI with Contrast (Gd-DTPA)



MRI Sequences

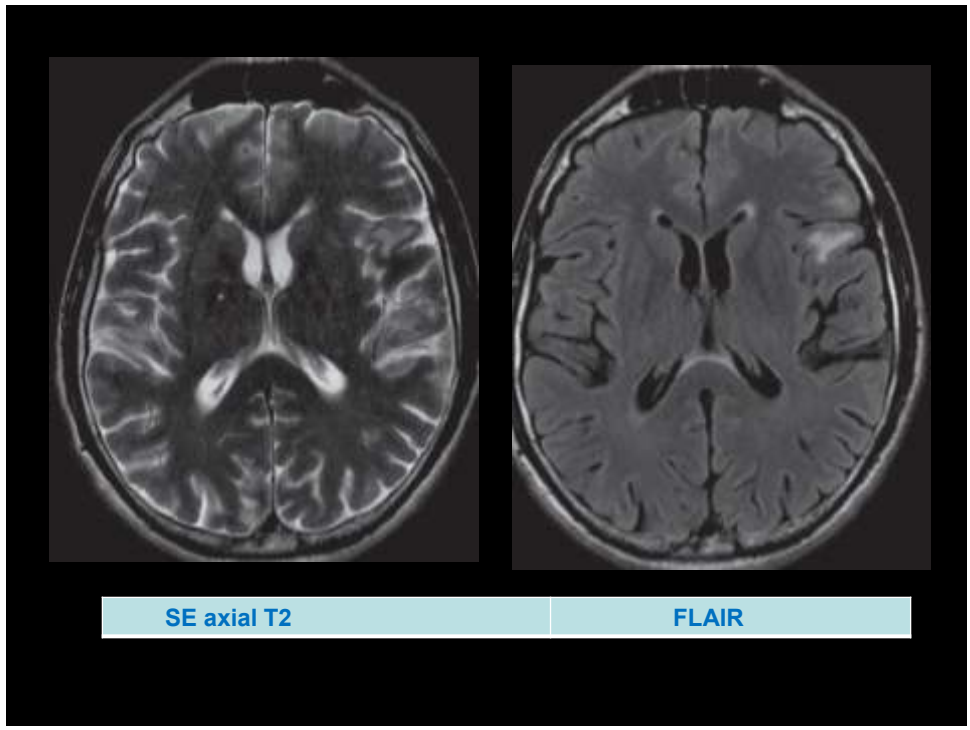


T1

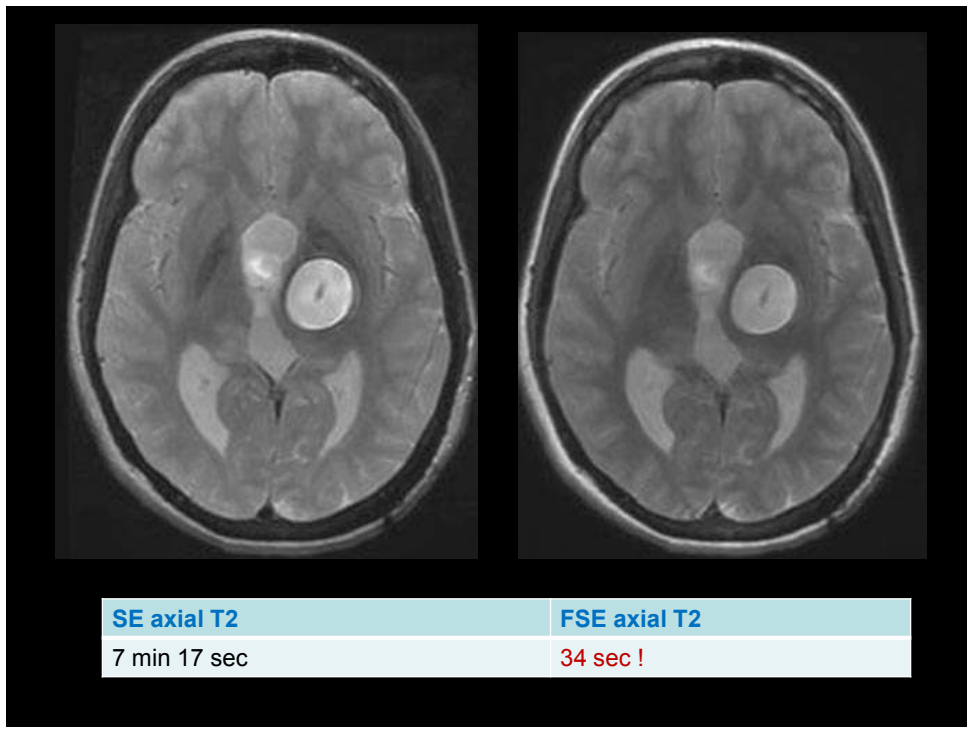


T2*

FLAIR



SE axial T2	FLAIR



SE axial T2	FSE axial T2
7 min 17 sec	34 sec !

Air / scar (no H^+)	Very dark	Very dark
Cortical bone (VEP)	Dark	Dark
Ligament / tendons	Dark	Dark
Calcifications	Dark	Dark
Fat (Dermoid, SC fat)		Dark
Bone marrow (yellow)		Intermediate
Protein		Intermediate
Fluid (CSF, ascitis, vitreous)	Dark	Bright
Heme = Acute blood	Intermediate	Intermediate
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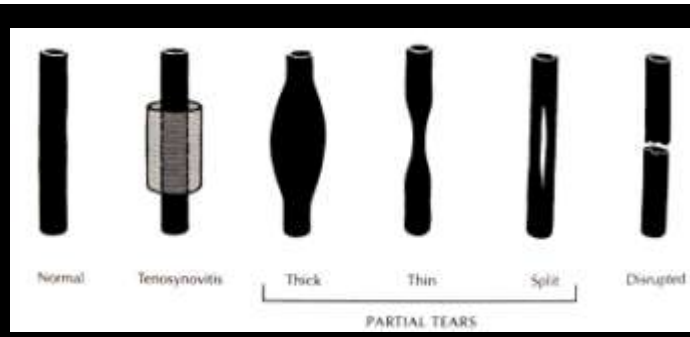


Msk Rule 1: Thick tendon + no fluid = chronic injury eg achilis

Msk Rule 2: Intermediate T2 signal = deg. / tendinits
High signal in a tendon on T2 = partial tear

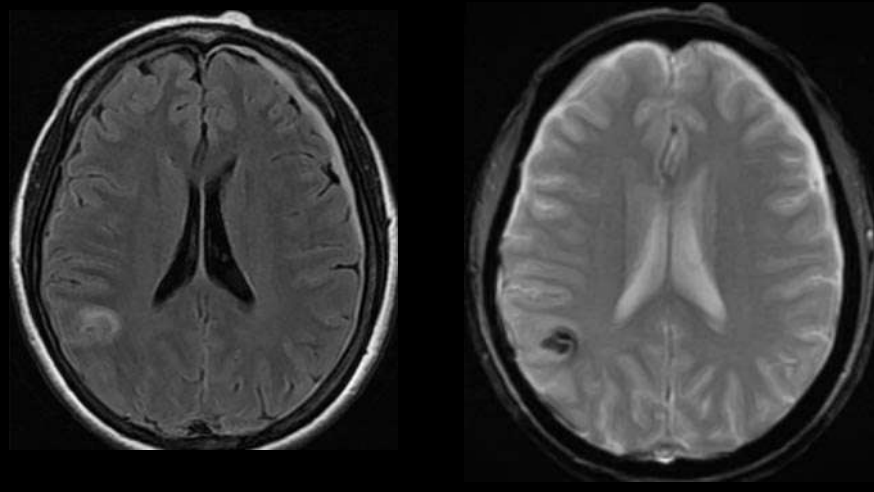
Msk Rule 3: 2 ligaments in body can split: peroneus brevis / biceps tendon

Msk Rule 4: Muscular injuries:

Grade I:	DOMS:	low T1 & high T2
Grade II:	Partial tear:	High T1 & T2
Grade III:	Complete tear:	low T1 & T2

Msk Rule 5: Tenosynovitis / stenosing T / Chronic tenosynovitis

	Time	Hemoglobin Type	Magnetism	T1w	T2w
Hyperacute	hours	Oxyhemoglobin	Diamagnetic	Iso	Bright
Acute	1-2 days	Deoxyhemoglobin	Paramagnetic – 4 unpaired electrons, however it cause no shortening	Iso	Dark
Early subacute	2-7 days	Methemoglobin (intracellular)	Paramagnetic – 5 unpaired electrons	Bright	Dark
Late subacute	1-4 weeks	Methemoglobin (extracellular so only causing changes in T2)	Paramagnetic – 5 unpaired electrons	Bright	Bright
Chronic	> 1 mth	Hemosiderin	Diamagnetic	Dark	Dark rim, central bright



Flair	T2 star (T2*)
4 min 17 sec	50 sec

PD = Proton density

YARA MOHAMAD ADEL
01-01-1982 KNEE F
PDW/SAG/512$ 27-10-2003,15:54

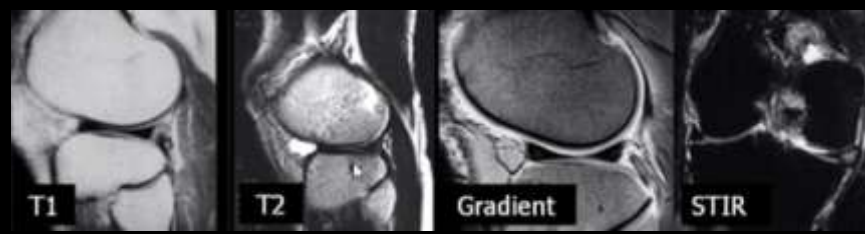
TR	1833	Slice	1/20
TE	17	Echo	1/1
		TSE Fact	4
SAGITTAL		RFOV	75%
TSE/M		FOV	220/1.9
ScTime:	2:58m	THK	3.5/0.4
			NSA 2
		Knee	256/512
AP	6	post	
RL	-12	right	
FH	-2	feet	
		Angle AP	3
		Angle RL	2
		Angle FH	4
HWAIDA			WW 1955
			WL 942

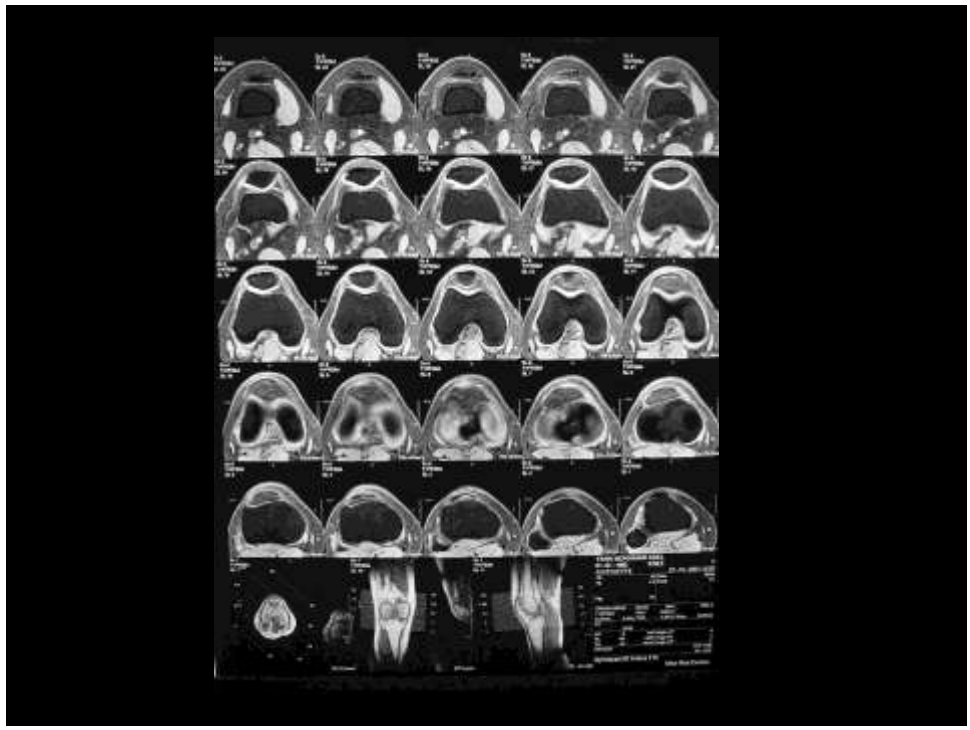
Gyroscan NT Intera T15

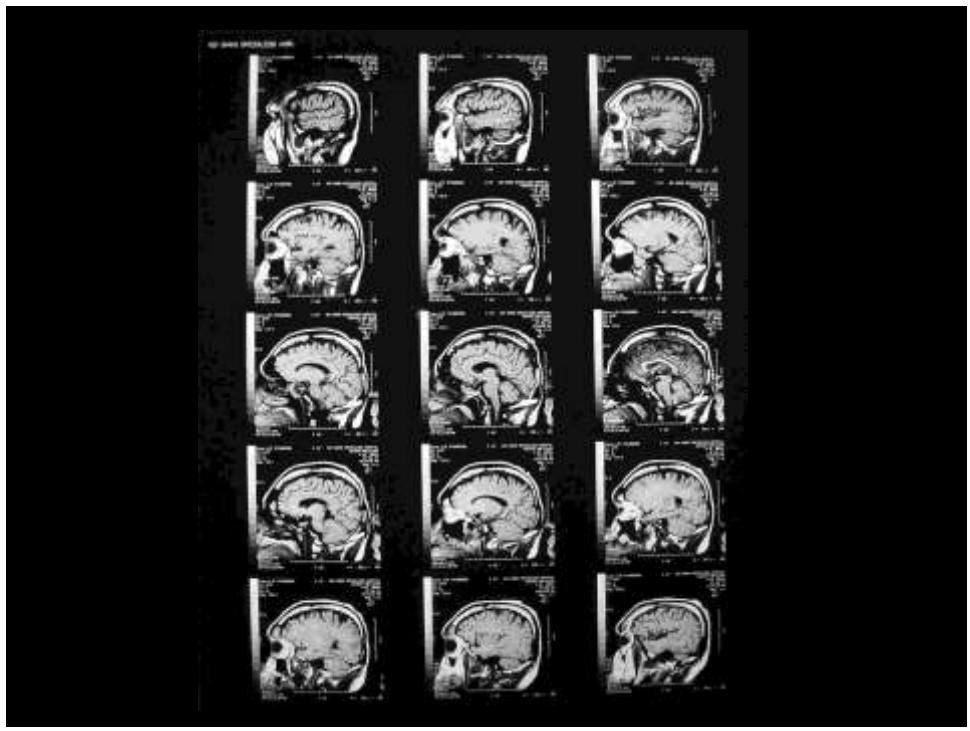
Bone Marrow

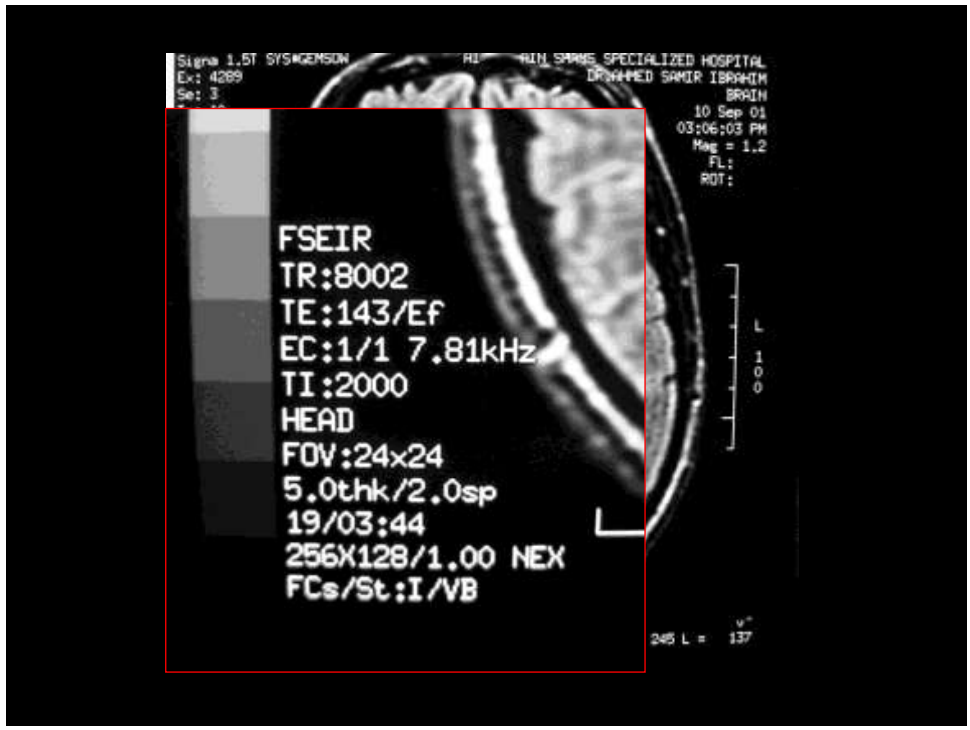
T1 white, T2 Intermediate

Gradient > black, STIR: completely black

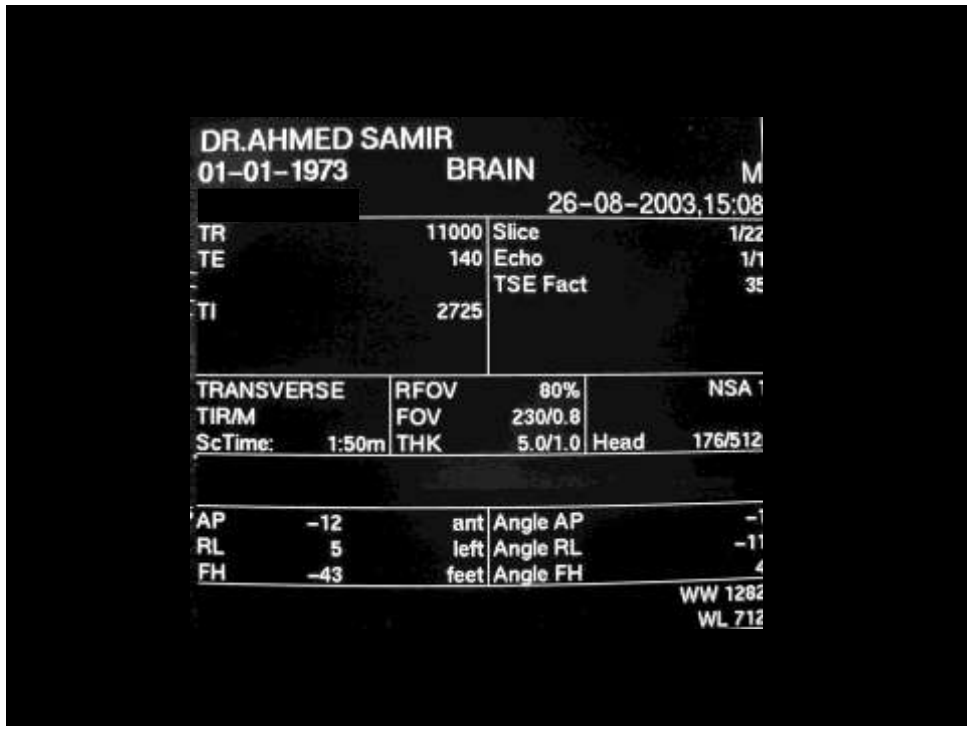


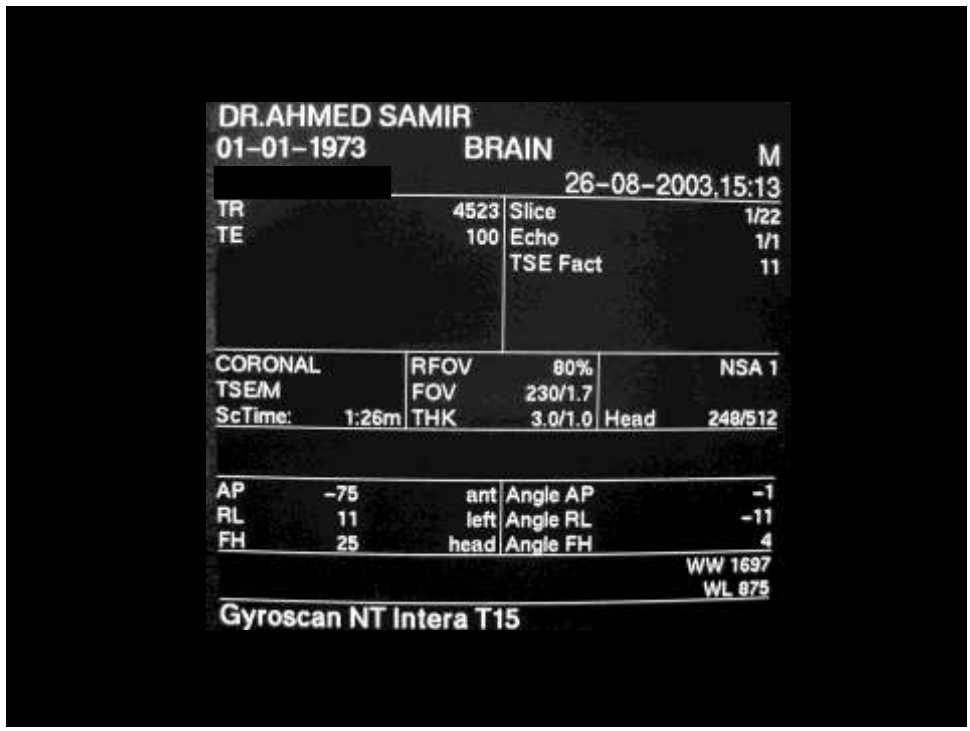


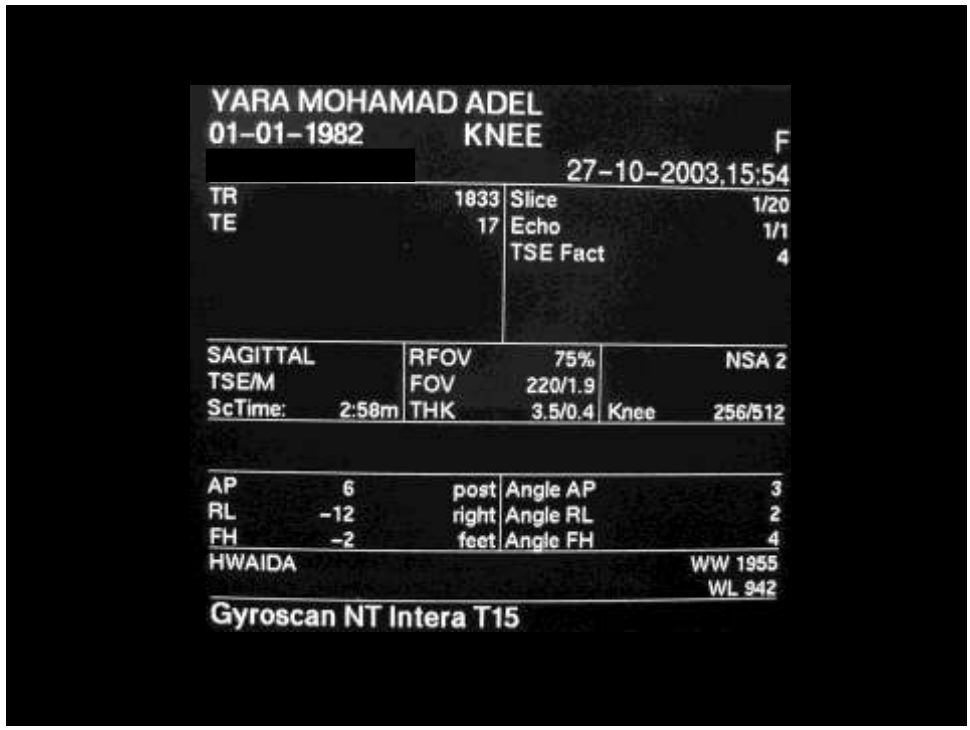


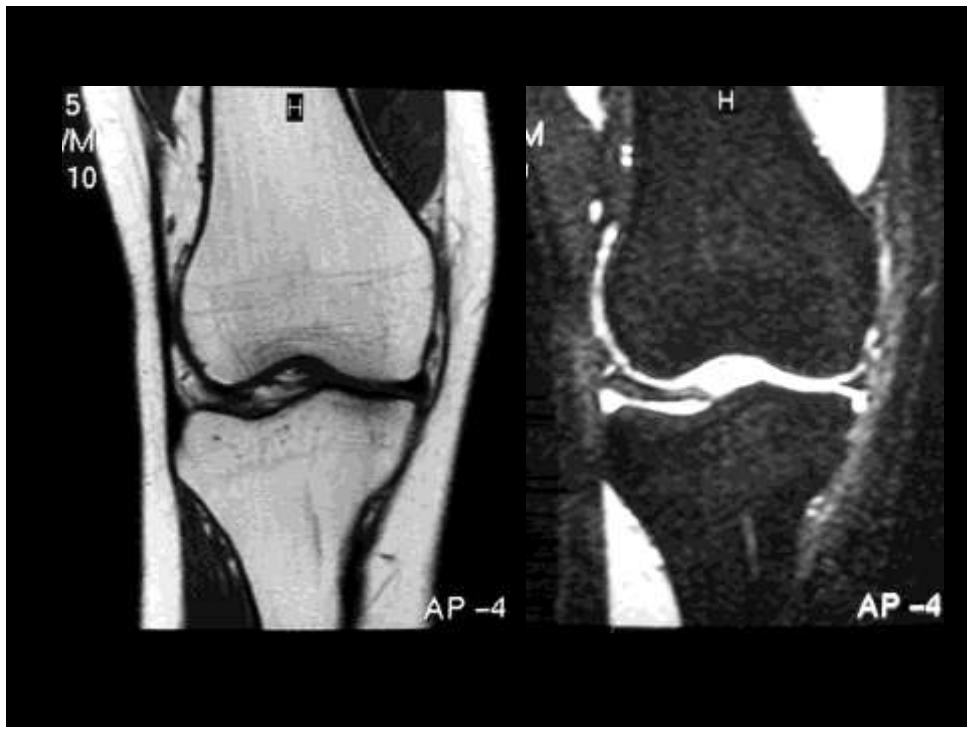

Signa 1.5T SYS#GEMSON
Ex: 4289
Se: 3
AIN SHAMS SPECIALIZED HOSPITAL
DR.AHMED SAMIR IBRAHIM
BRAIN
10 Sep 01
03:06:03 PM
Mag = 1.2
FL:
ROT:
FSEIR
TR:8002
TE:143/Ef
EC:1/1 7.81kHz
TI:2000
HEAD
FOV:24x24
5.0thk/2.0sp
19/03:44
256X128/1.00 NEX
FCs/St:I/VB
L
1
0
0
245 L = 137


OSag L10.1
02:04:0
Mag =
FL:
ROT:
FSE
TR:740
TE:22/Ef
EC:1/1 31.2kHz
HEAD
FOV:24x24
5.0thk/2.0sp
16/04:00
256X160/2 NEX
FCf/St:I/VB/TRF

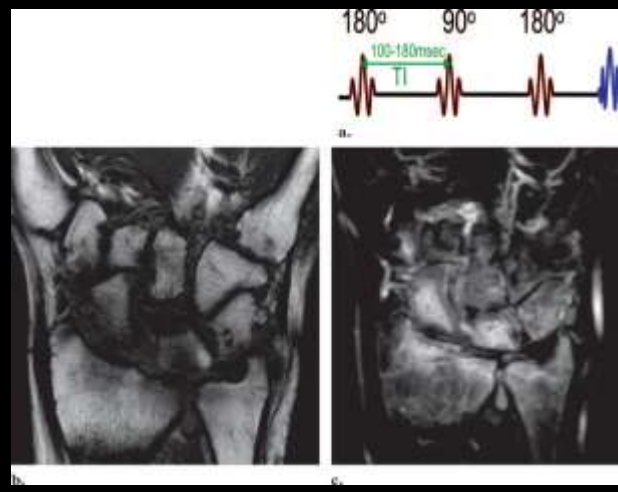

DR.AHMED SAMIR
01-01-1973
BRAIN
M
26-08-2003,15:08
TR 11000
TE 140
TI 2725
Slice 1/22
Echo 1/1
TSE Fact 35
TRANSVERSE
TIR/M
ScTime: 1:50m
RFOV 80%
FOV 230/0.8
THK 5.0/1.0
NSA 1
Head 176/512
AP -12 ant
RL 5 left
FH -43 feet
Angle AP -1
Angle RL -11
Angle FH 4
WW 1282
WL 712


DR.AHMED SAMIR
01-01-1973
BRAIN
M
26-08-2003,15:13
TR 4523
TE 100
Slice 1/22
Echo 1/1
TSE Fact 11
CORONAL
TSE/M
ScTime: 1:26m
RFOV 80%
FOV 230/1.7
THK 3.0/1.0
NSA 1
Head 248/512
AP -75 ant
RL 11 left
FH 25 head
Angle AP -1
Angle RL -11
Angle FH 4
WW 1697
WL 875
Gyroscan NT Intera T15


YARA MOHAMAD ADEL
01-01-1982
KNEE
F
27-10-2003,15:54
TR 1833
TE 17
Slice 1/20
Echo 1/1
TSE Fact 4
SAGITTAL
TSE/M
ScTime: 2:58m
RFOV 75%
FOV 220/1.9
THK 3.5/0.4
NSA 2
Knee 256/512
AP 6 post
RL -12 right
FH -2 feet
Angle AP 3
Angle RL 2
Angle FH 4
HWAIDA
WW 1955
WL 942
Gyroscan NT Intera T15


5
/M
10
H
AP -4
H
AP -4

Role of STIR is crucial in Msk !



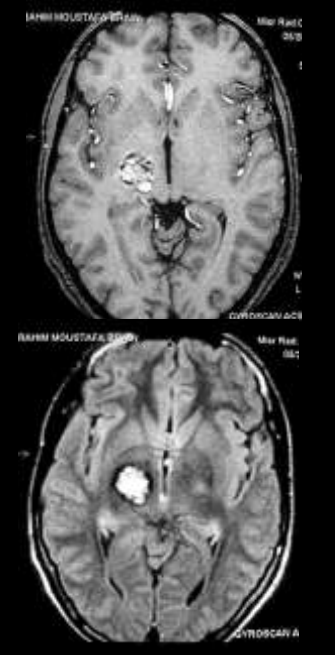
Gradient Echo

(10 - 35 ^{0} pulse sequences)

- Gradient Echo sequences
  - Large Flip angle = T1 w
  - Long TE = T2* w

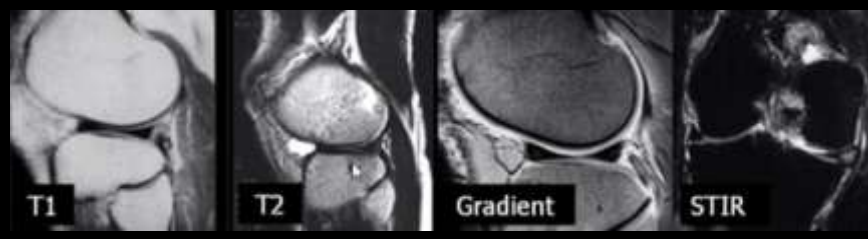
Characteristics:

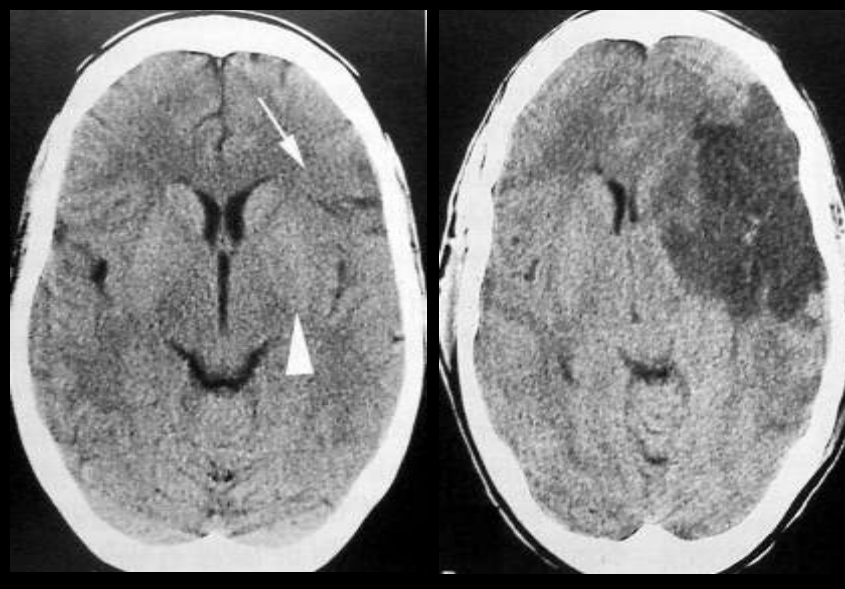
- Short time
- Intense SI from vessels
- Flip angle 10-35^{0}



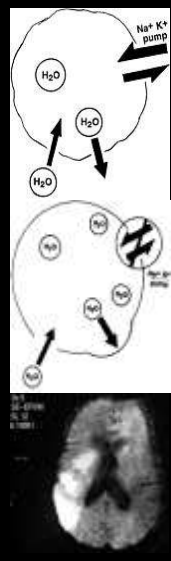
Bone Marrow

T1: white
T2: Intermediate
Gradient: > black
STIR: Completely black



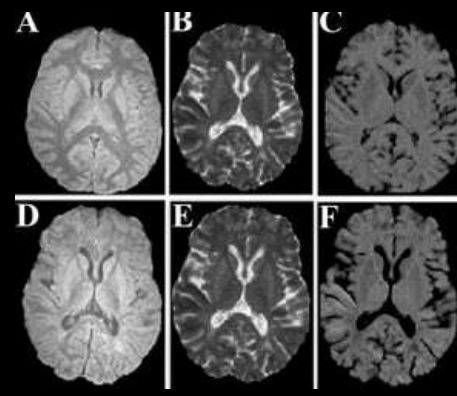


Special sequences: DWI

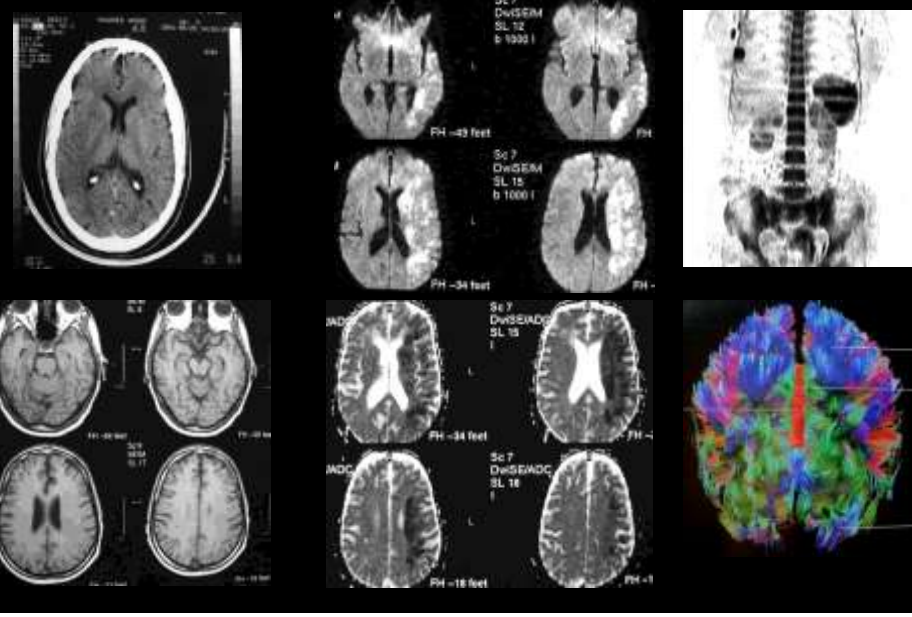


EPI = Echo plannar imaging

MTI = Magnetization Transfer Imaging



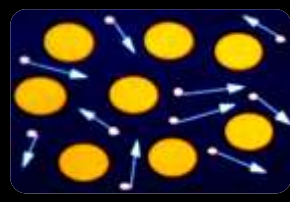
MR Diffusion (EPI)

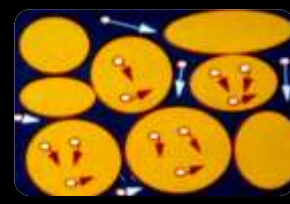


Diffusion / ADC biological basis:

"DWI is the only imaging modality able to depict the random motion of water in tissues"

DWI 0: *as T2w*
DWI 500: *for ccc of any areas of restriction*
DWI 1000: *for calculation of ADC values (never in LN< 5mm)*
DWI 2000: *done for prostatic & ovarian pathologies*



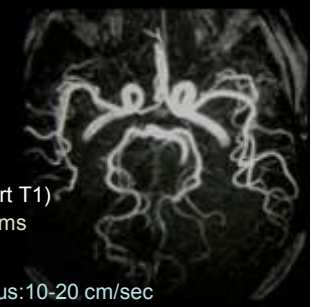


In malignancies
↓
The more cellular packing
↓
The less extracellular space
↓
The less diffusivity of water Molecules
↓
The less the ADC value eg. < 0.9

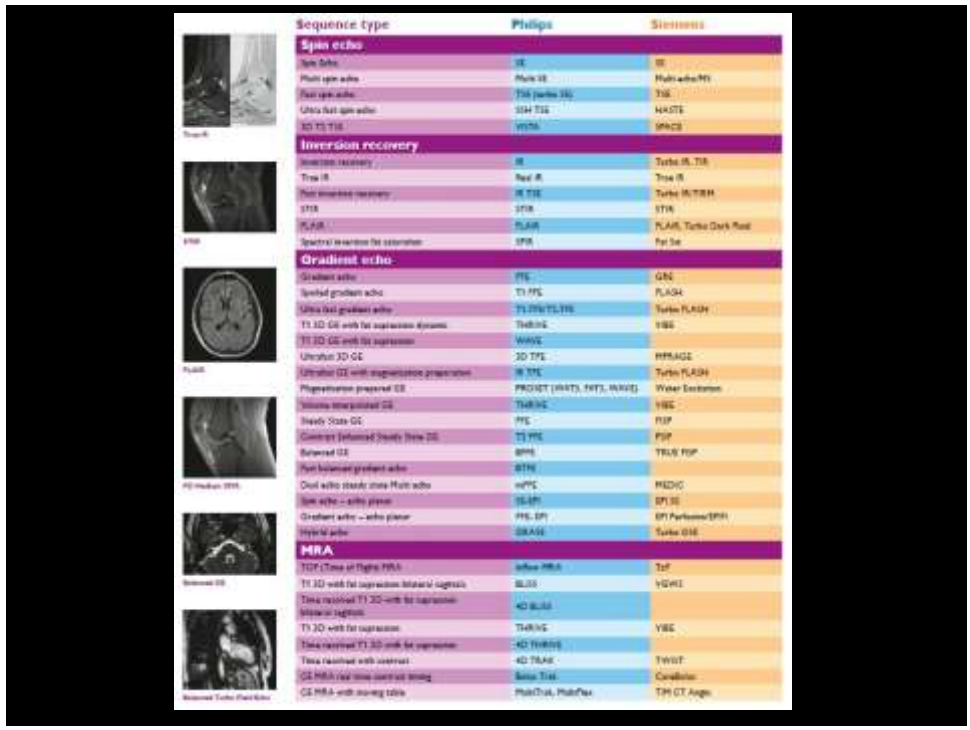
>1.2 mm^2/s = normal/benign
0.9-1.2 mm^2/s = equivocal
<0.9 mm^2/s = malignant

ADC values are directly $\propto$ to water diffusivity

MRA sequences



- Time of flight (TOF): 2D or 3D
  - GE images related to flow movement
  - To separate venous/arterial = pre-saturation slab
  - Best for: small arteries, veins, aneurysm…..shows hge (short T1)
  - Good for high flow arteries & weak in low flow venous systems
- Phase Contrast (PC): Arterial:90 – Nidus:40 – Venous:10-20 cm/sec
  - Employs phase + shift of MR signal dt flow, i.e. all stationary tissues are suppressed (e.g. hge inside of an AVM is suppressed)
  - Longer imaging time
  - Don't forget its role in: CSF flowmetry
- Gd Enhanced MRA
  - On conventional injection: artery and veins are seen together
  - Pump Bolus tracking
  - Allows to grade stenosis: e.g 5-15 mm loss of SI = > 75% stenosis



MRI Sequences

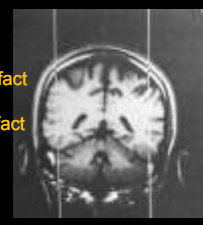
SE based sequences	GRE sequences
Long, Flip angle 90, RF pulse	Short, variable flip angle, variation of gradient

• **Fast SE variant**
• **Inversion recovery:**
  • STIR (SPIR): short T1 IR
  • FLAIR: fluid attenuated IR
	• **Fully refocused GRE:** SSFP (cardiac)
	• **Partially refocused GRE**: MRA
	• **Coherent (refocused)**
	• **Incoherent (spoiled):**
	  • Post-GD GRE-T1
	  • In phase / Out phase (abdominal MRI)
	• **Phase contrast:** Angio MRA, MRV, mixed
	• **DWI / ADC:**
	  • Echoplannar Imaging (EPI)
	  • Fast GRE
	• **Fat signal suppression (Fat saturation tech)**

GE	Siemens	Philips
GRASS Spoiled GRASS SSFP IR-GRASS	FISP FLASH FISP TurboFLASH	FFE T1 CE FFE T2 CE FFE FTE

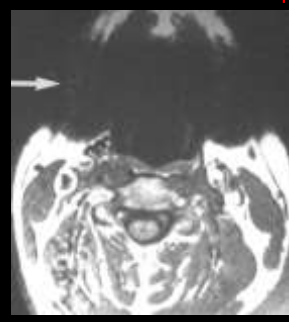
MR Artifacts

1- Wrap around (aliasing)
2- Gibbs artifact (truncation)
3- Magnetic susceptibility artifact
4- Motion artifact
5- Transverse coherence artifact
6- Flow artifact
7- Chemical artifact

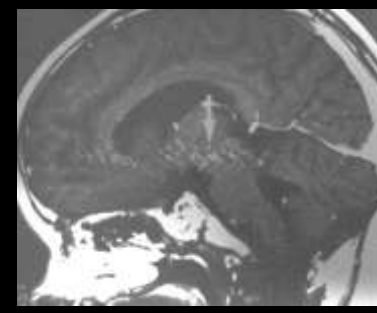


Wrap around (aliasing)

Chemical artifact



Magnetic susceptibility artifact



Motion artifact

Part II

Neuro/Spine Anatomy & Protocols

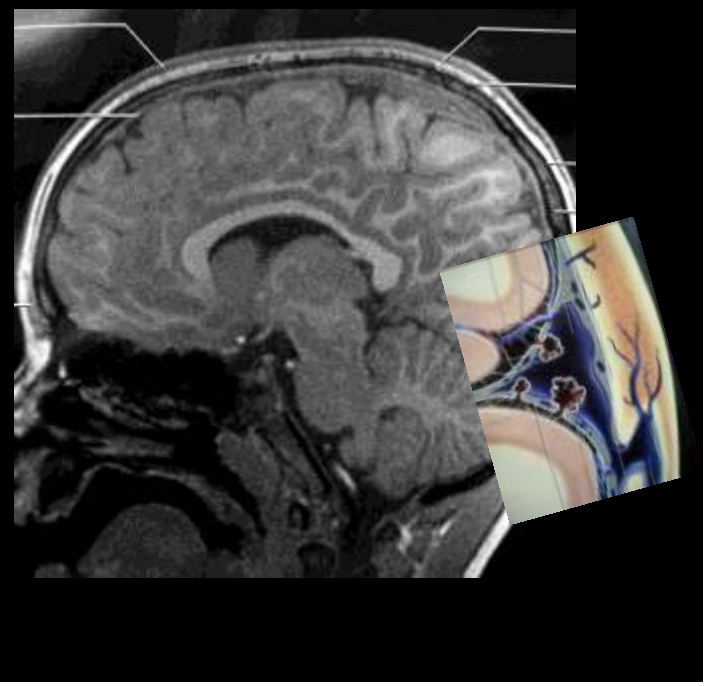
- Neuro MRI
- Sella
- Temporal
- Head & neck

Brain MRI
Anatomy/protocols

Anatomy-based Imaging issues

Imaging pitfall

i. Thick skull is a normal variant
ii. Hyperostosis of frontal bone is common in old F
iii. Calvarial lucencies are to be DD with Mets (go for fat suppression)
iv. Giant granulations not to be mistaken for thrombus



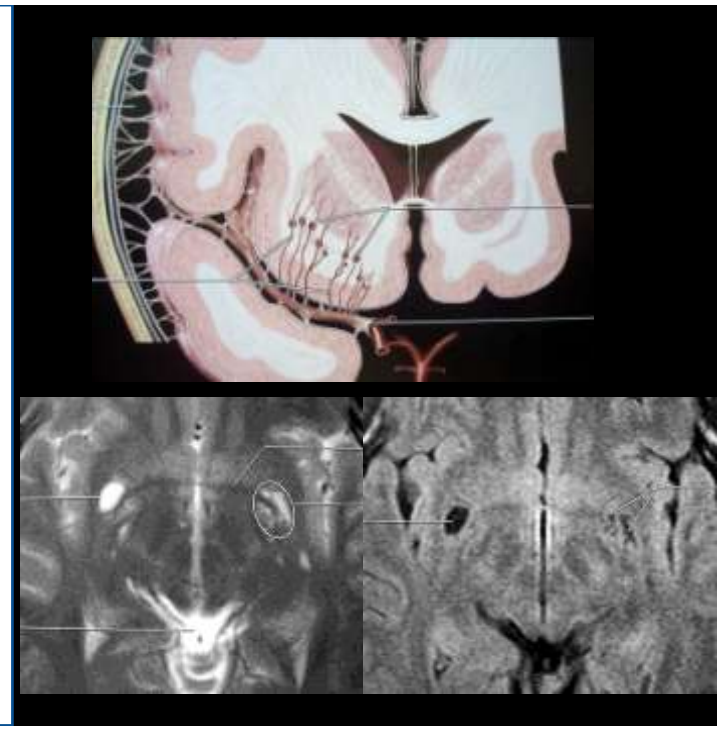
Anatomy-based Imaging issues

Imaging pitfall

i. Flair is used to DD PVSs (suppressed) from lacunar infarct (not suppressed)

i. PVSs are mainly seen on 1.5T and more on 3T machines

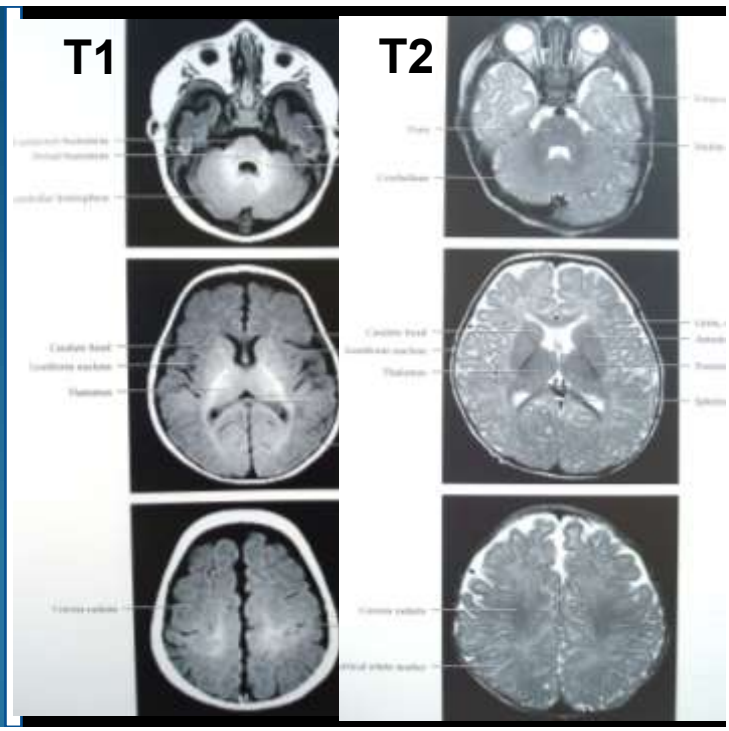
i. PVSs: perivascular spaces are filled with ISF communicating with SAS



Anatomy-based Imaging issues

Imaging pitfall

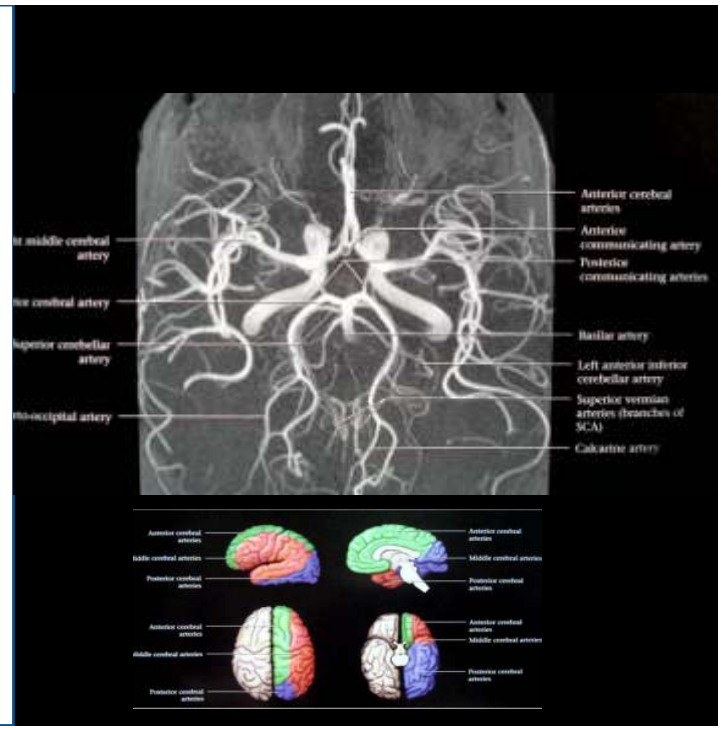
i. WM maturation
   i. 1st 6m: T1
   ii. 2nd 6m: T2
iii. 1st 6m: T1 is as adult T2
iv. 2nd 6m: T2 is as adult T1
v. Myelination inf to sup-central to peripheral-posterior to anterior



Anatomy-based Imaging issues

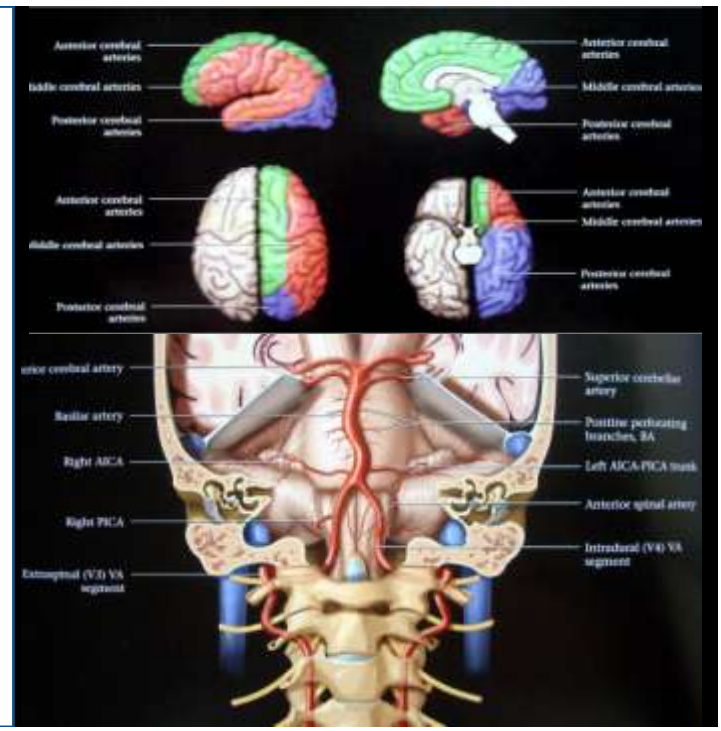
Imaging pitfall

i. CNS arterial supply
ii. Absent COW is usually congenital



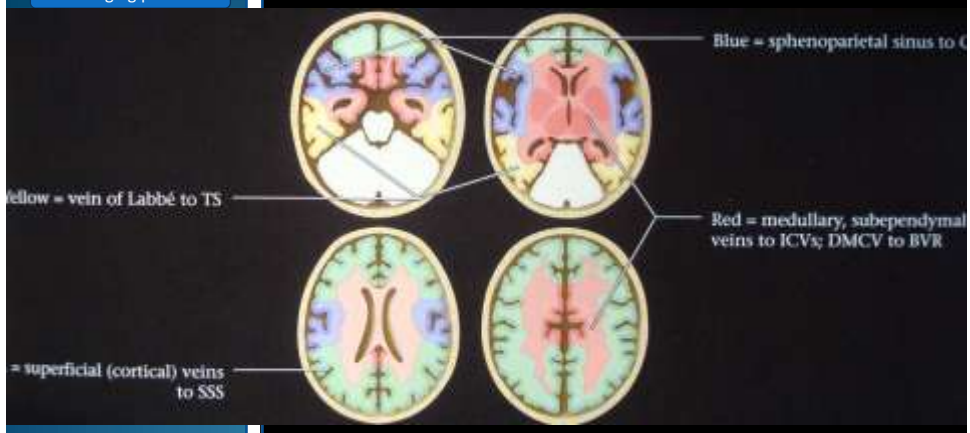
Anatomy-based Imaging issues

Imaging anatomy



Anatomy-based Imaging issues

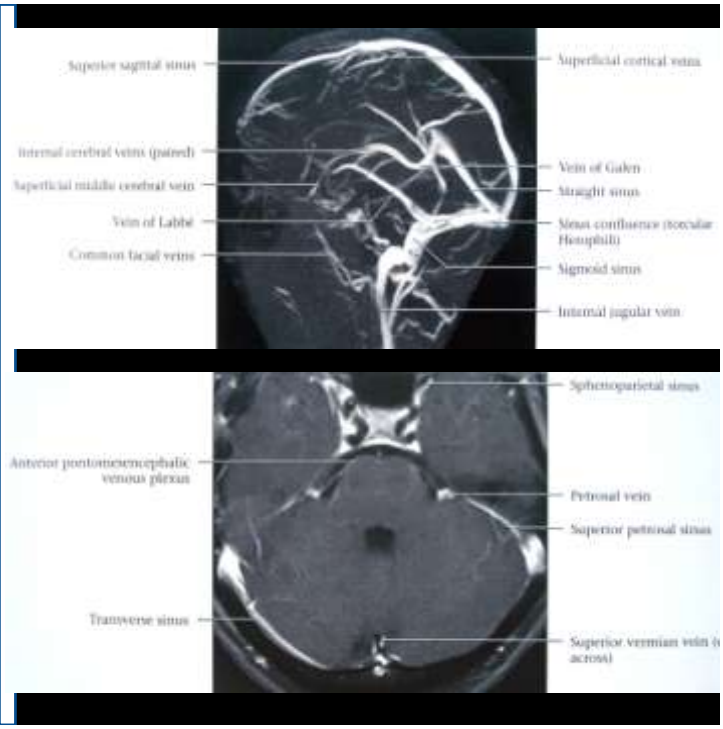
Imaging pitfall



Anatomy-based Imaging issues

Imaging pitfall

i. CNS Venous drainage



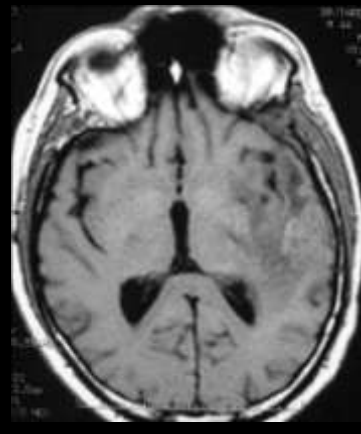
MR Brain protocol

1. T1 W axial
2. T2 W axial

3. T1 W sagittal
4. T2 W coronal

5. FLAIR axial
6. DWIs Axial

Brain MRI



MR Brain stroke protocol

Stroke add to routine:
- SWI
- DWI EPI + ADC Map
- T2* W axial (FFE) (sensitive to hemosiderin)
- 3D T.O.F. MRA for Brain

If hyperacute stroke: (i.e.< 6 hrs)
- Axial T1 W, FLAIR
  Then do:
- Perfusion dynamic (post Gd-DTPA)

Advanced Neuro functional MR techniques

- Susceptibility weighted imaging (SWI)
- MR Spectroscopy
- MR Perfusion
- DTI & Tractography
- Functional MRI (f-MRI)

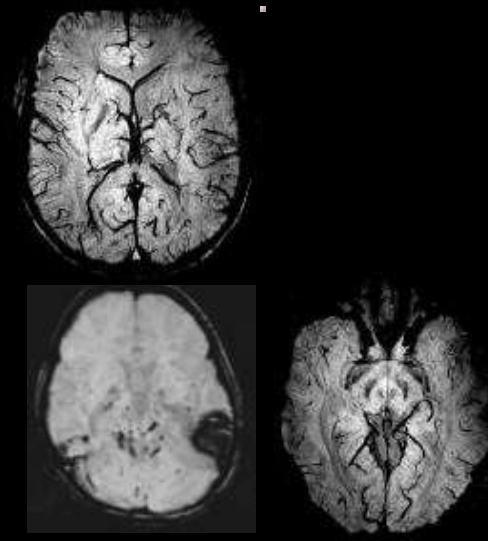
SWI

Susceptibility Weighted Imaging = Venous BOLD

3D velocity compensated
Gr. echo sequence

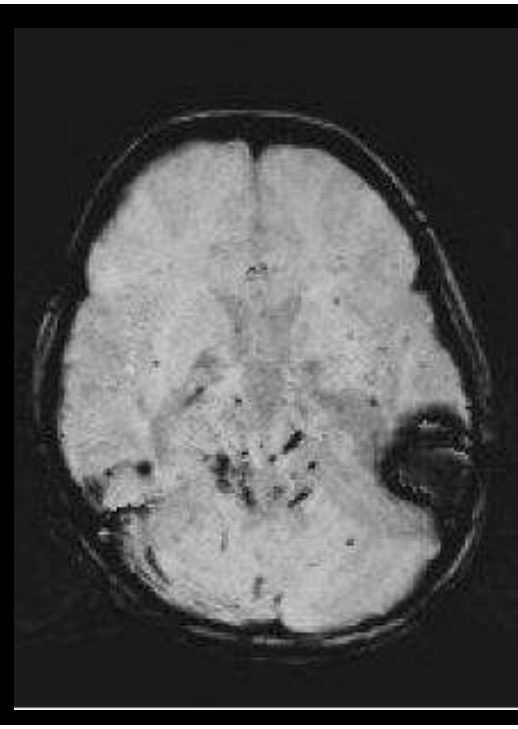
Applications:

1. Venous ischemia: sinus thrombosis
2. Axonal injury
3. Hgic infarction
4. Non-aneurysmal SubA hge
5. AVM
6. Amyloid angiopathy
7. PRESS
8. Demyelinating diseases: high Fe
9. Hge in tumrs: microhge, neovessels



SWI

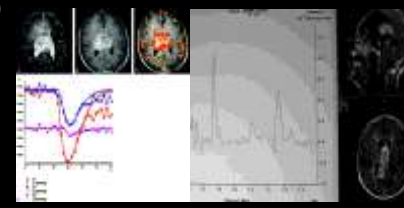
Susceptibility
Weighted
Imaging



MR Brain protocol

For tumors, inflammatory etc…add to routine

- T1 W axial + c (MTC)
- T1 W coronal + c (Fat suppression)
- T1 W sagittal + c
- MR Spectroscopy (MRS), DTI
- T2* perfusion
- 4D T1 perfusion



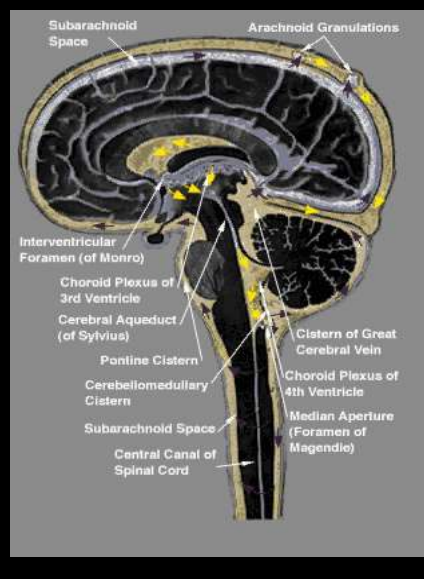
Epilepsy add to routine:

- FLAIR coronal (thin cuts 3/0 // to temporal lobe).
- T2W coronal (thin cuts3/0// to temporal lobe).

Multiple sclerosis add to routine:

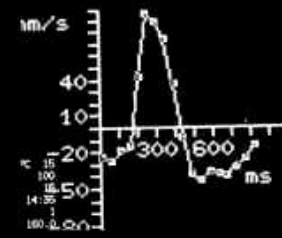
-T2 W sagittal

CSF flowmetry

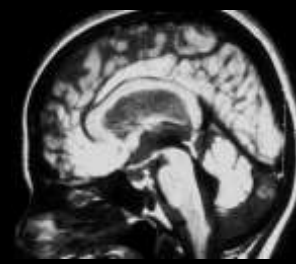


Hydrocephalus (NPH)

- **T1 W sagittal**
- **PD axial**
- **Phase Contrast** (10 cm/sec)



Functioning

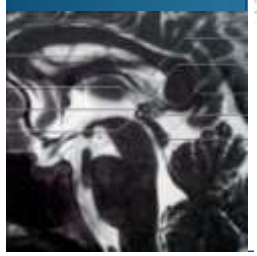


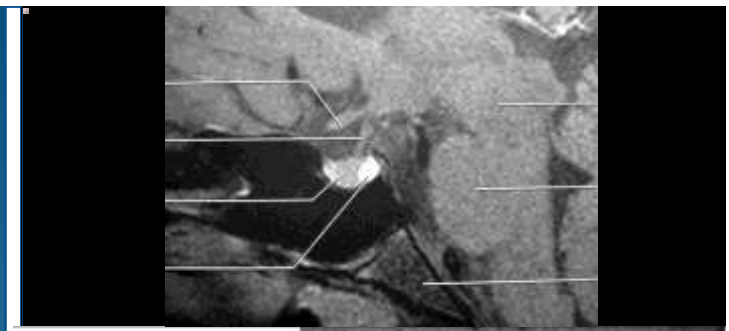
Mal-functioning

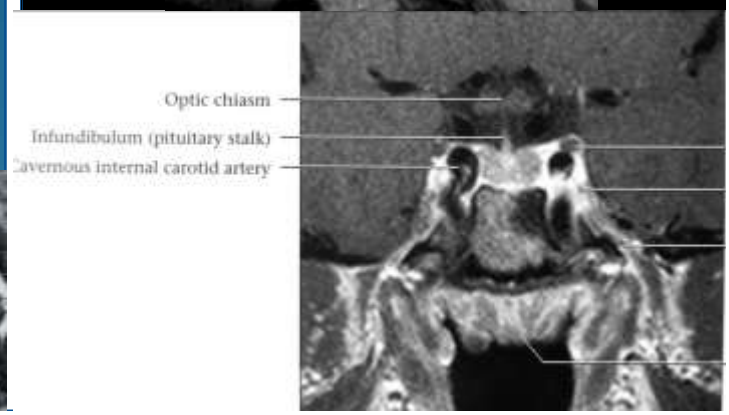
Anatomy-based Imaging issues

Imaging pitfall

i. Non C T1 Fat sat showing T1 shortening in NH = PPBS = post pituitary "bright spot"
ii. < 6mm in children, 8mm in males up to 10-12 mm in F (post M, lactating preganancy)
iii. Clivius low signal till 25 yrs, then high fat S
iv. Empty sella
v. Pineal cyst > 1cm are to be follow up (B pineal cysts are common)







MR Sella protocol

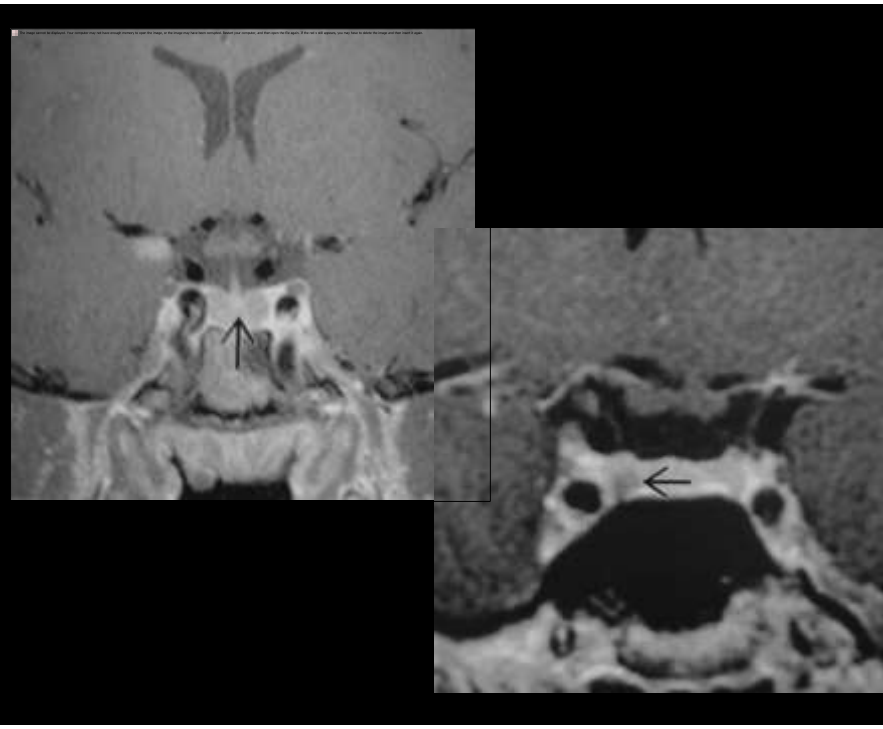
Sella : Macro-adenoma, craniopharyngioma, cyst, etc..
- T2 W axial brain
- T1 W sagittal sella
- T1 W coronal sella

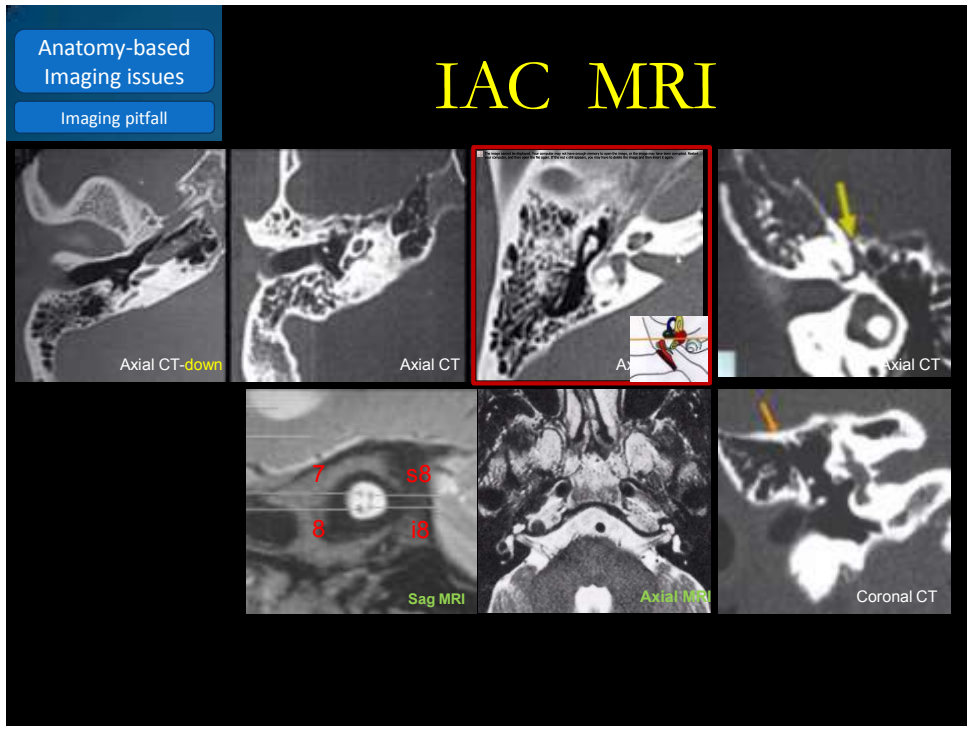
Injection Contrast
- T1 W coronal sella
- T1 W sagittal sella

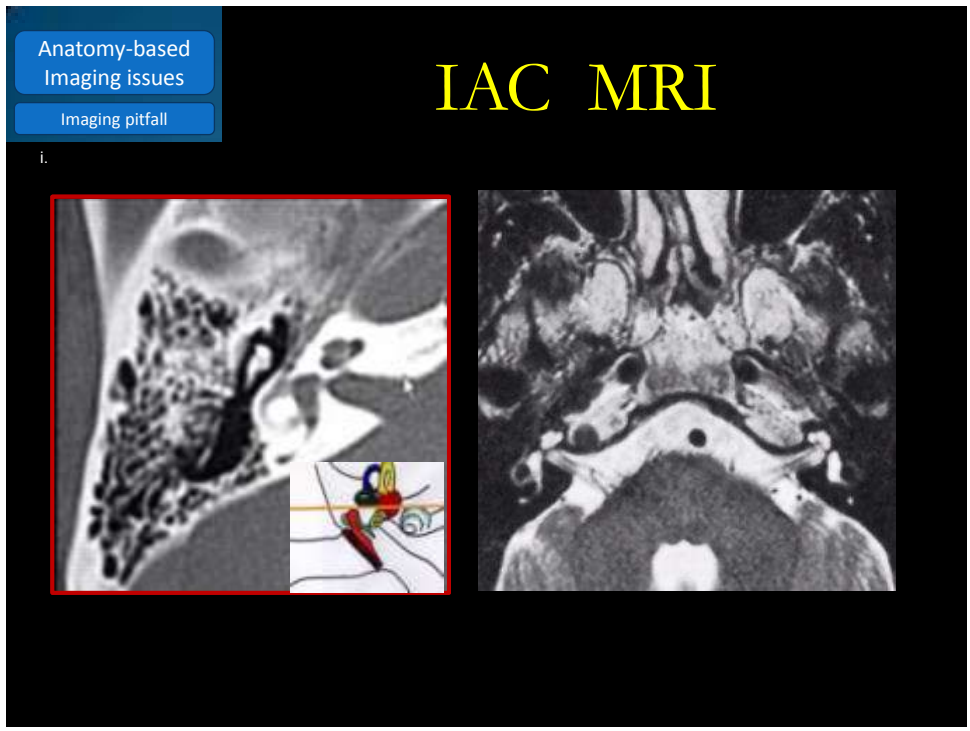
Important: in case of post-operative sella do post contrast T1 coronal & sagittal e fat suppression

Micro-adenoma (hyperprolactinaemia):
- T2 W axial brain
- T1 W sagittal sella
- T1 W coronal sella

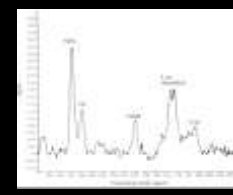
Post injection do:
- Coronal (dynamic: 5 positions, 5 phases)
- T1W Coronal Delayed
- T1 W sagittal




Anatomy-based Imaging issues
Imaging pitfall
IAC MRI
Axial CT-down
Axial CT
Axial CT
7
s8
8
i8
Sag MRI
Axial MRI
Coronal CT


Anatomy-based Imaging issues
Imaging pitfall
IAC MRI
i.

Spectroscopy: MRS chemicals



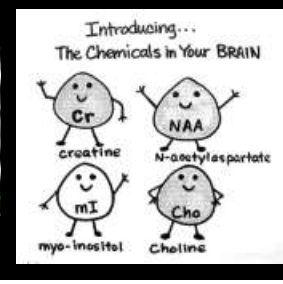
1- NAA: a marker of neuronal integrity.

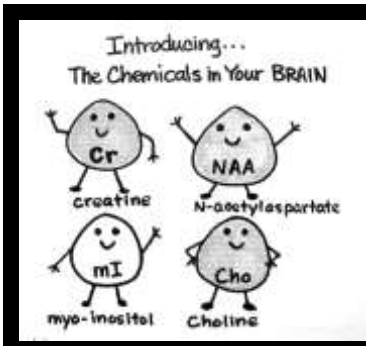
2- Choline: a marker of cell membrane turnover.

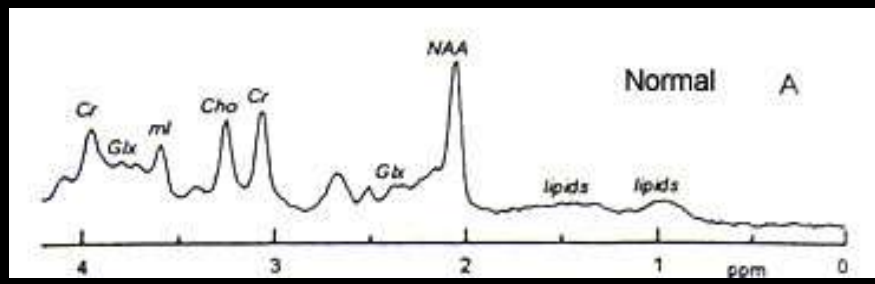
3- Creatinine: a marker of cell energy & osmotic balance.

4- Lactate: refers to tumor hypoxia & anaerobic metabolism.

5- Lipids: refers to cellular necrosis

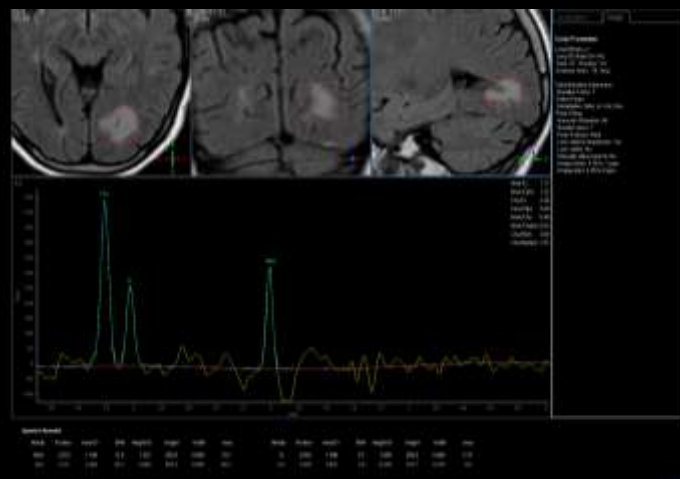




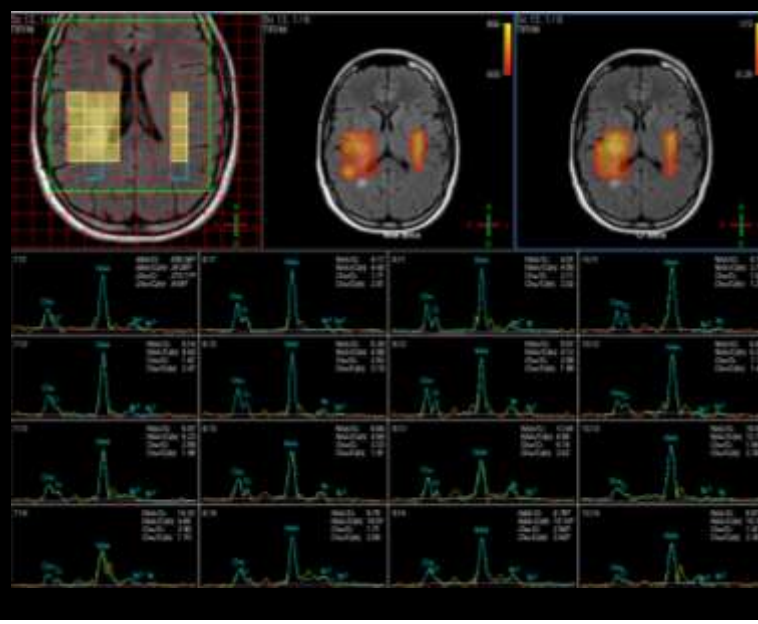


MRS = Spectroscopy

I- Single-voxel techniques

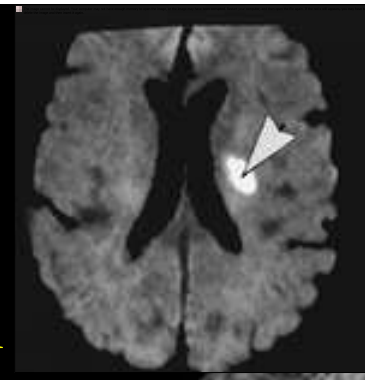


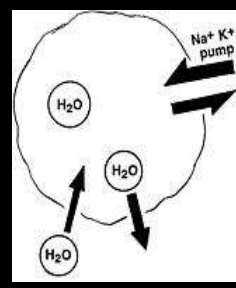
II- Multi-voxel techniques



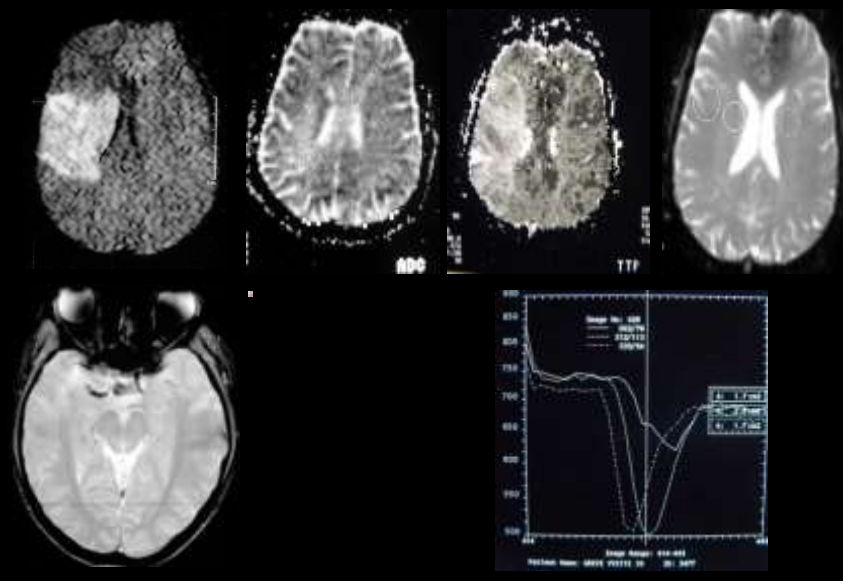
Diffusion & DTI (tractography)

Diffusion MR



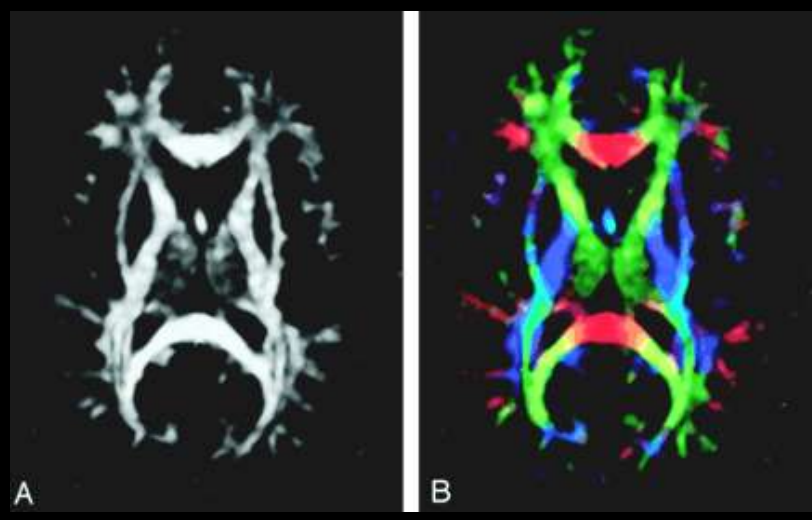


Stroke Protocol (7 min full exam !)



Fractional Anisotropy (FA)

Corresponding 2D directional color map

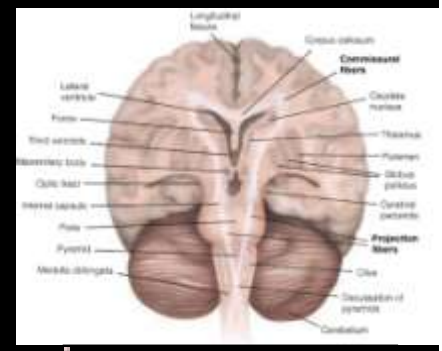


Types of White Matter fibers

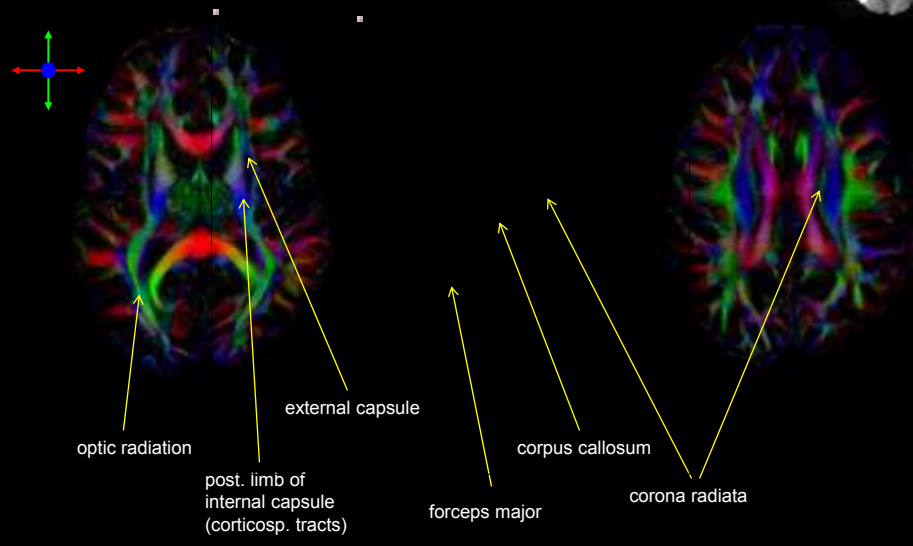
1) **Commisural fibers:** between both cerebral lobes
e.g. corpus callosum

2) **Projection fibers:** between cortical center and deep nuclei
e.g. corticospinal

3) **Association fibers:** between cortical centres e.g. arcuate fasiculus between Wernicke's & Broca's areas.



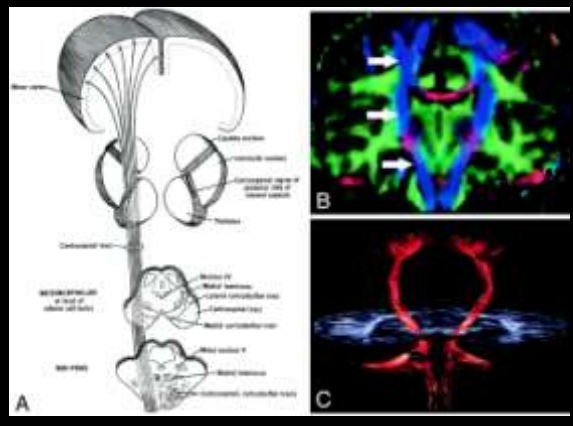
3T SENSE-DTI: Fractional Anisotropy (FA)

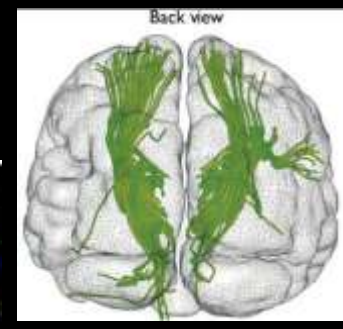


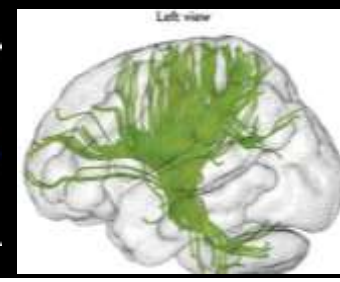
High resolution (256x256) color coded FA map
R=2.4 TE=101*ms* 4 scans (each NSA=4)

Normal Anatomy of DTI tractography

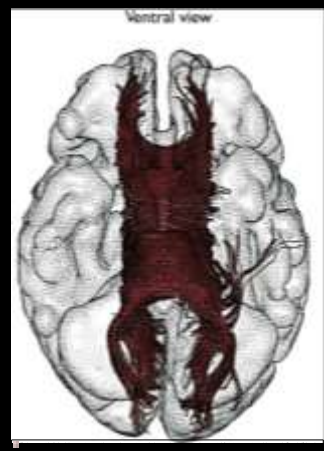
Corona radiata 3D

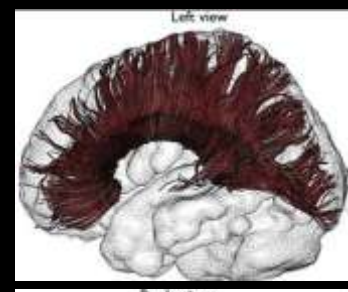


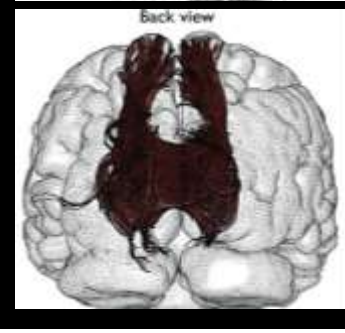




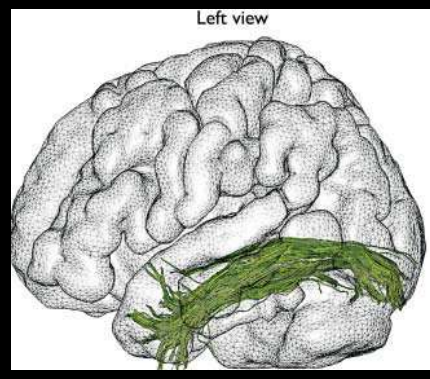
Corpus callosum

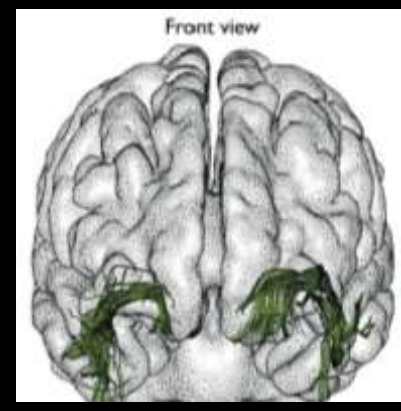






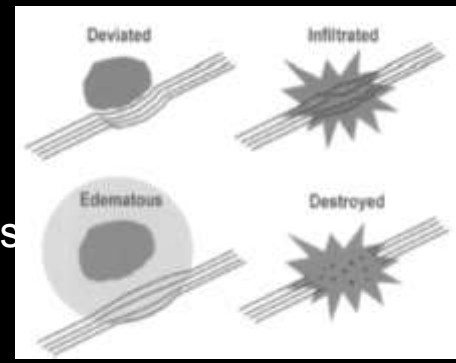
Inferior longitudinal fasciculus.





Effects of Brain Tumors on white matter tracts as determined by DTI & MR Tractography

1) Deviation
2) Infiltration
3) Edematous changes
4) Destruction

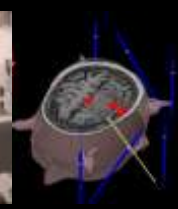


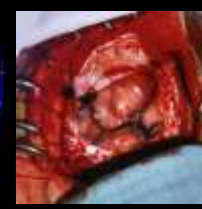
Quoted from Jellison et al., AJNR, 2004

Wb-MRI: Diffusion / DWIBS

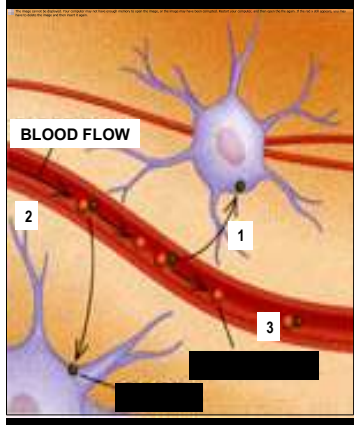
Diffusion Weighted Whole Body Imaging
with Background Body Signal Suppression

Functional MRI (fMRI)





Visualising the brain at work (BOLD)



Increase in neuronal activation

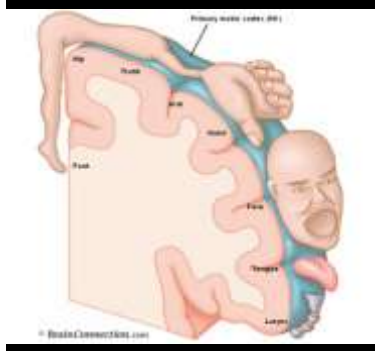
Slight increase in O_2 extraction (1)
+
Large increase in perfusion (2

Increase oxyHb in capillary & venous blood / decrease deoxyHb (3)

Increase in T2* MR signal

Quoted from Stephan Sunnert, MD

fMRI sensorimotor mapping

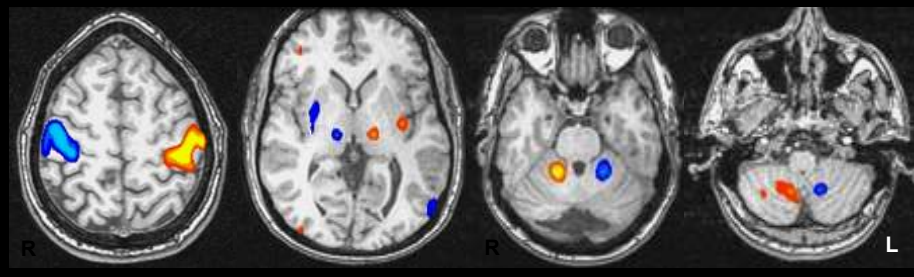


Post

Ant

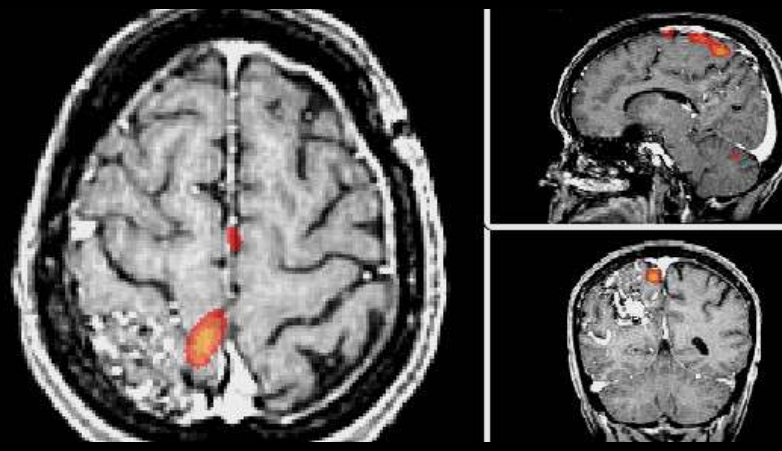
hands, feet and mouth

fMRI sensorimotor paradigms

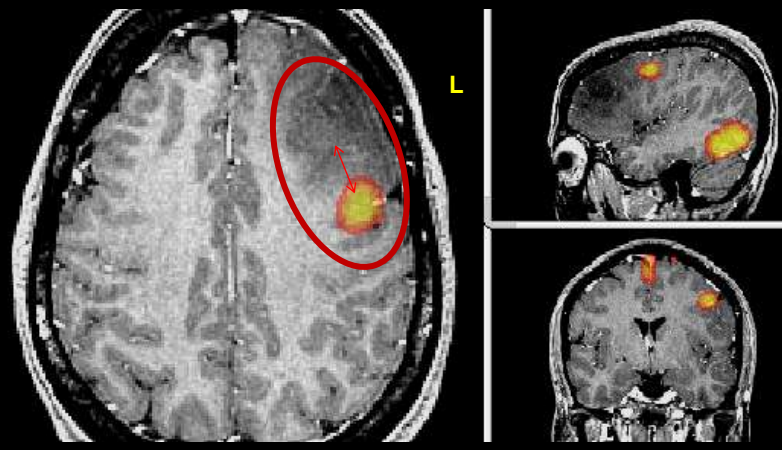


Yellow/orange = right hand Blue/cyan = left hand

Foot / ankle motion



High risk (< 1 cm.)



Orbits & Brain

- T2 W axial brain
- T1 W axial (orbits)
- T2 W axial (orbits)
- T2 W oblique sagittal (both orbits)

Post Injection:

- T1 W coronal SPIR (orbits).
- T1 W axial SPIR (orbits).
- T1 W oblique sagittal SPIR (both orbits)

Orbit: fat suppression

Anatomy-based Imaging issues

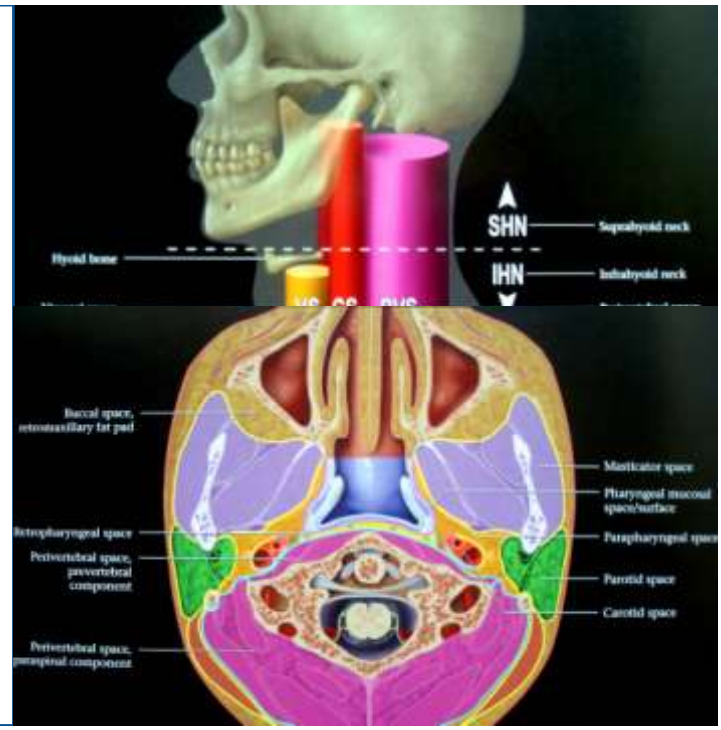
Imaging pitfall

i. Orbit & chiasma

Anatomy-based Imaging issues

Imaging pitfall

i. Base of the skull & neck
ii. Parapharyngeal space (PPS)



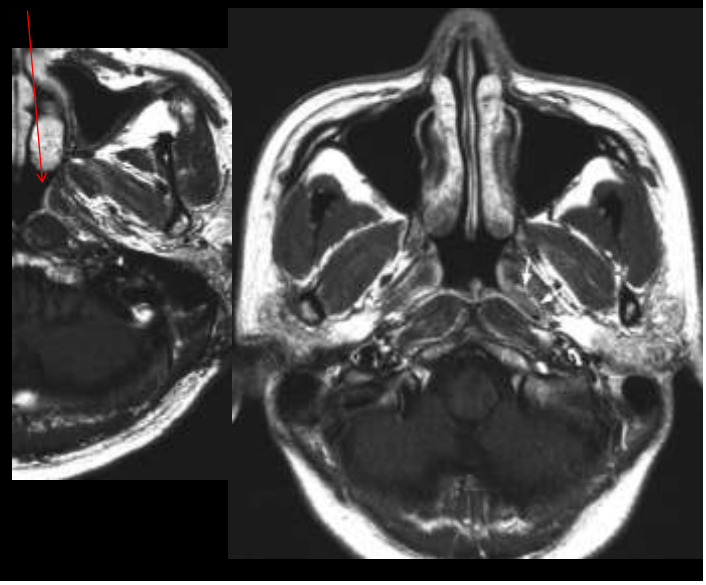
Anatomy-based Imaging issues

i. Nasopharynx

Above: Eustachian tube

Torus tubarius = T & L veli palati

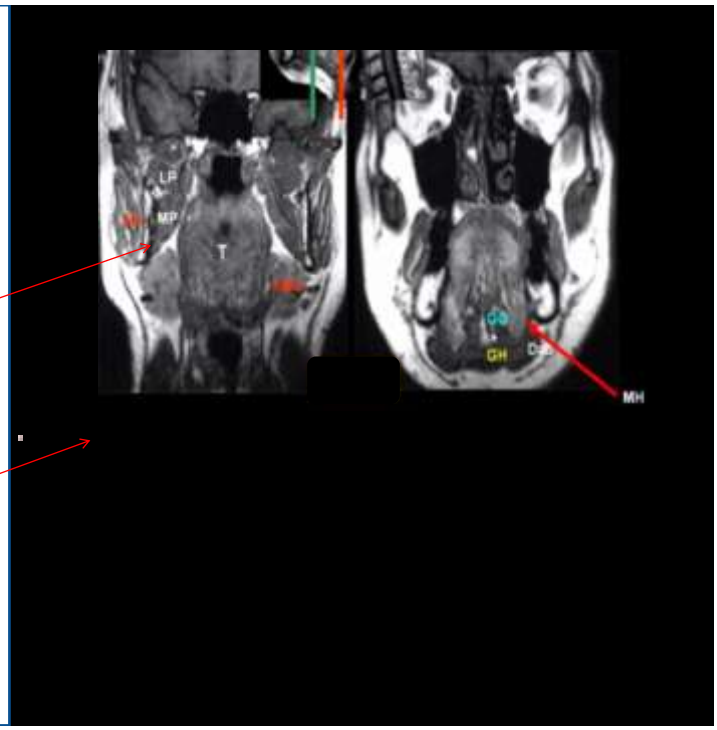
Below: fossa of Russenmuller



Anatomy-based Imaging issues

Imaging pitfall

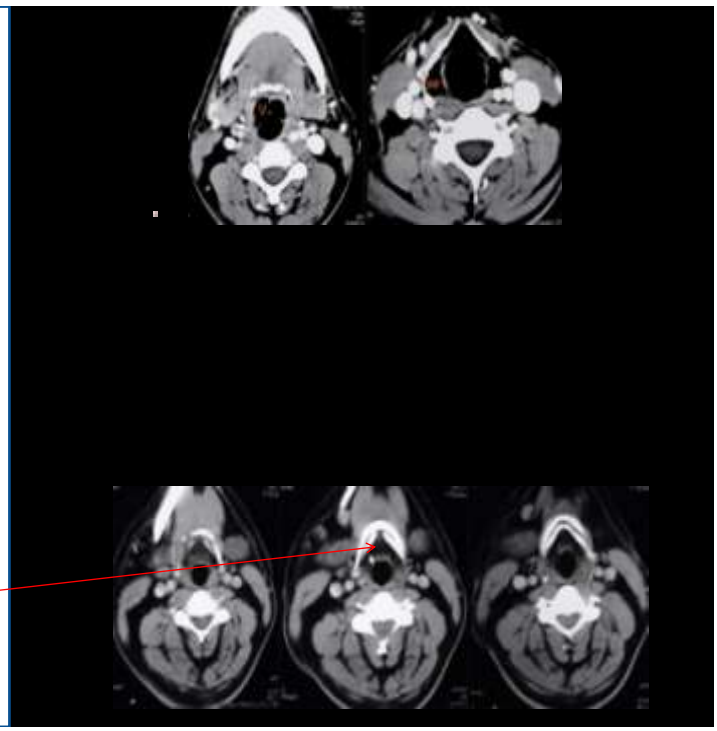
i. Axial: geno glossus
ii. Below it: geno-hyoid

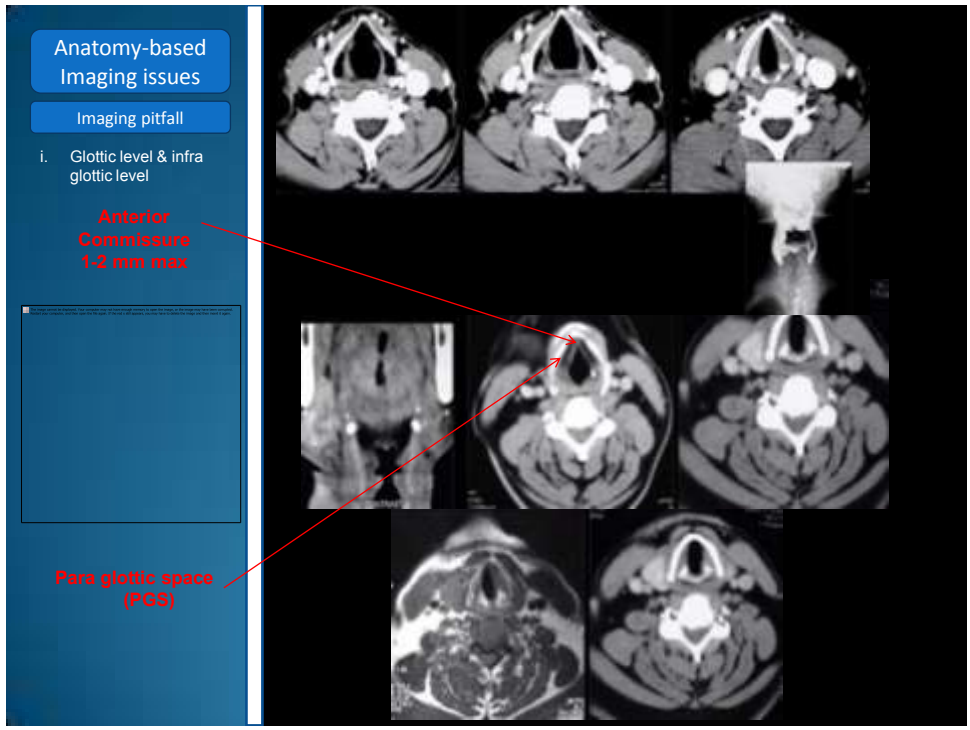


Anatomy-based Imaging issues

Imaging pitfall

i. Glottic level
ii. Glosso – epiglottic fold / 2 valeculae
iii. Ary-epiglottic fold / 2 piriform fossae



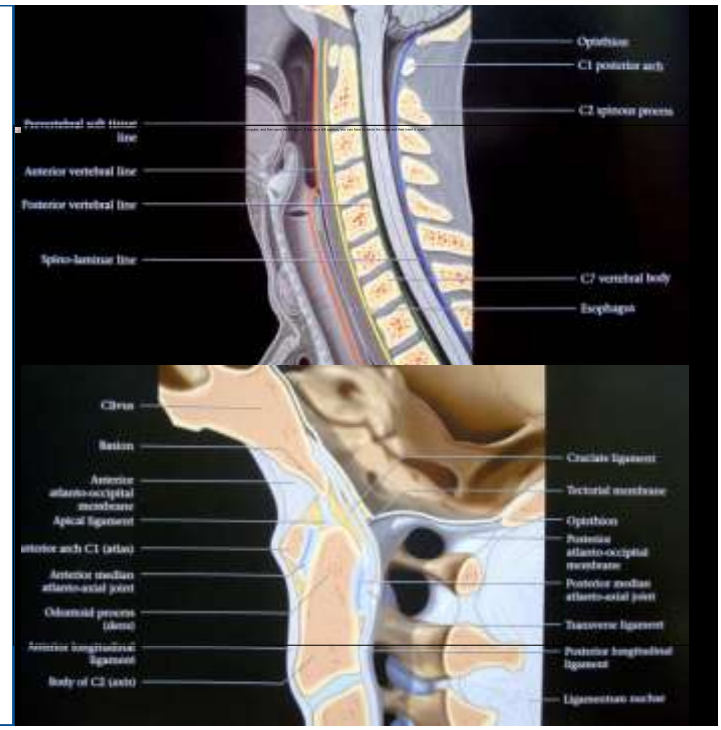

Anatomy-based Imaging issues
Imaging pitfall
i. Glottic level & infra glottic level
Anterior Commissure 1-2 mm max
Para glottic space (PGS)

Spine MRI

Anatomy-based Imaging issues

Imaging pitfall

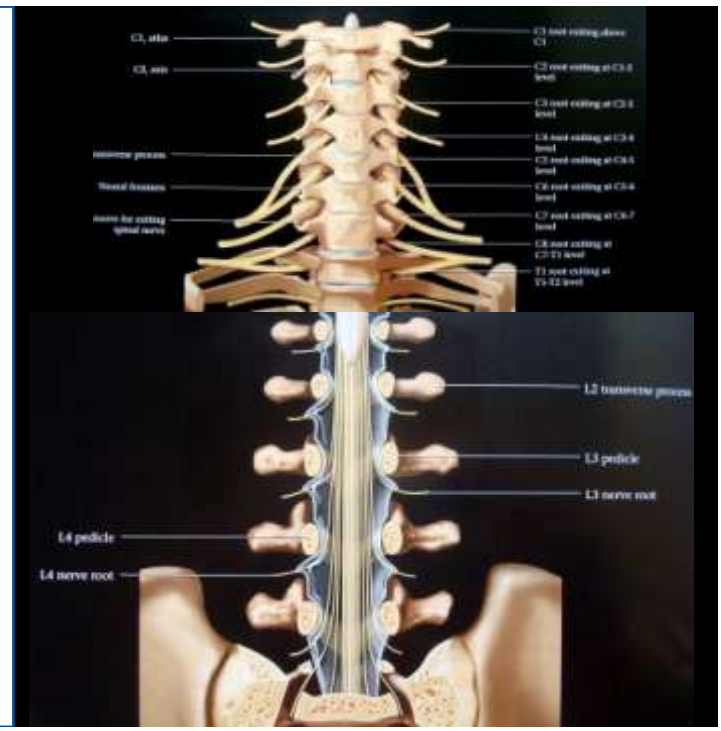
i. 7,12,5,5,4 is found in only 5% of population
ii. Big L5 transverse process = sacralized lumbar vertebrea
iii. Elevated S1 above sacral fusion = lumbarized sacrum
iv. Lumbar/sacralization may need whole spine numbering from C2 downward
v. Cerebellar herniation



Anatomy-based Imaging issues

Imaging pitfall

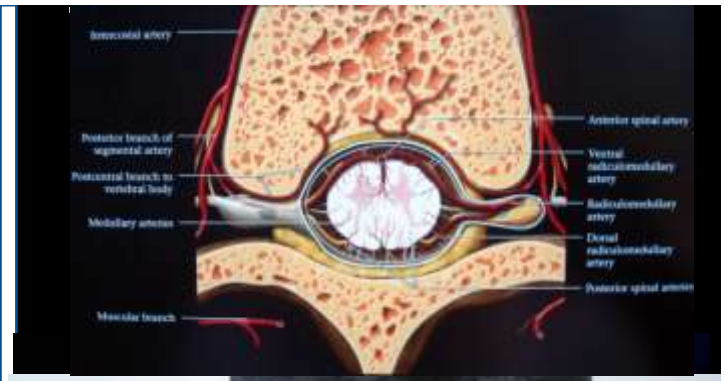
i. Nerve roots
ii. C7 transverse vertebrae goes down
iii. T1 transverse vertebrae superolaterally

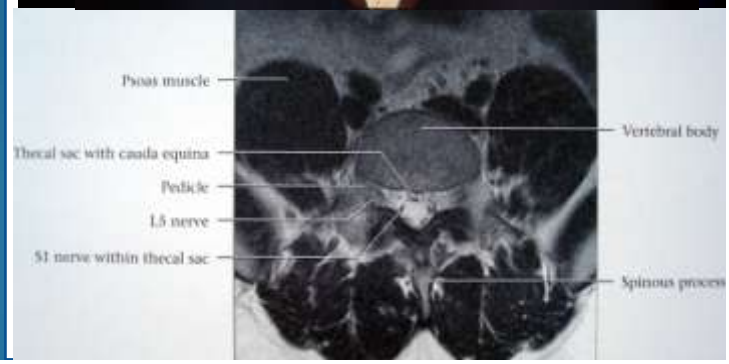


Anatomy-based Imaging issues

Imaging pitfall

i. Vascular water shed area of the cord = central grey matter
ii. ASA affects ant2/3 of the cord
iii. Hypotensive infarcts affects central grey matter

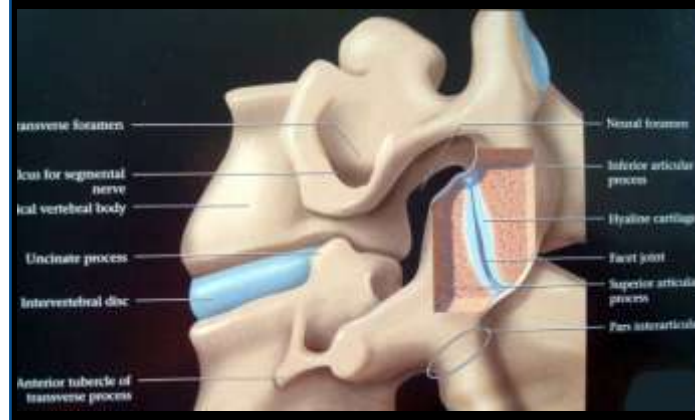




Anatomy-based Imaging issues

Imaging pitfall

i. Spondylosis = pars interarticularis fracture
ii. Spondylolisthesis = slip of vertebrae
iii. Tropism = vertebral facet zygapohyseal joint asymmetry (sever >16degree)



Cervical Spine p.

- T2 W sagittal
- T1 W sagittal
- T2 W axial (stack) on discs
- T2* W axial FFE (volume).

+ Post contrast: T1 W axial & sagittal +/-SPIR

Lumbar Spine p.

- T2 W sagittals
- T1 W sagittals
- T1 W axials
- T2 W axials

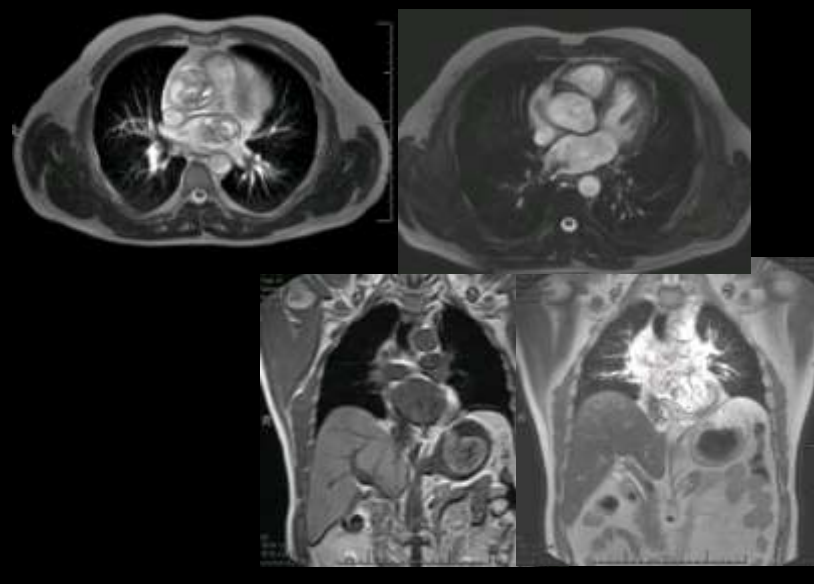
+ Post contrast: T1 W axial & sagittal SPIR

Part III

Body/Msk Anatomy & Protocols

Body MRI

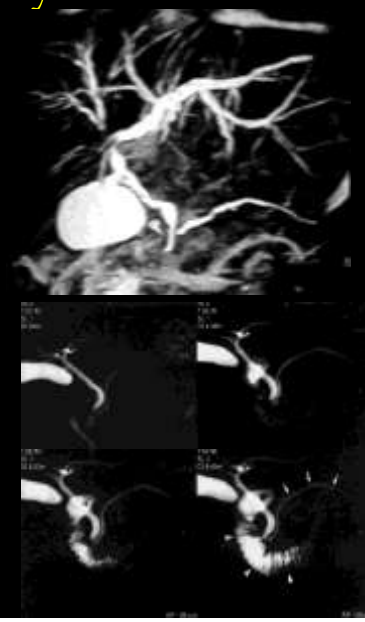
CMR: Chest MRI is now possible



MRCP: Biliary MRI

- T2W Axial
- DWI Axial
- BFFE Axial + Coronal

- Single shot MRCP (4-6 shoted)
- 3D MRCP

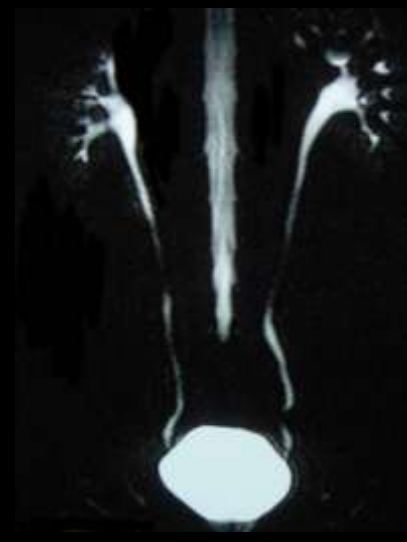


MRU Urography

Cuts must cover whole abdomen + pelvis

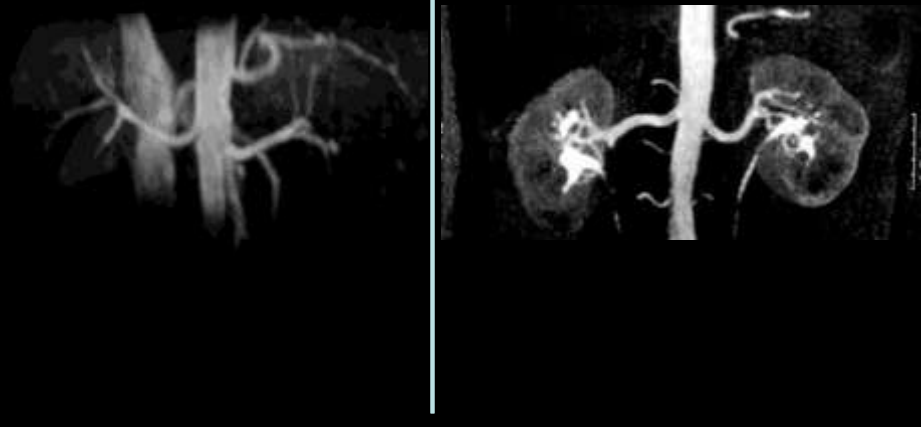
- T2W Axial
- DWI Axial
- BFFE Axial + Coronal

- Single shot MRU Sagittal on each kd
- 3D MRU



Renal MRA

Phase contrast (PC) – Time of flight (TOF)



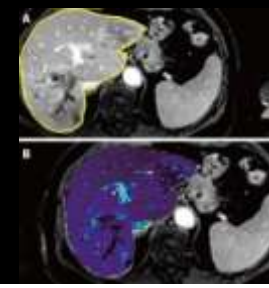
MRI Abdomen (5 mm slice thickness)

- T2W Axial
- T2W Axial SPIR (with fat suppression)
- T2W Axial Heavy T2 (for ccc of hep. focal lesions)
- DWI (Liver 3b values: 0, 200, 800) / (Kd 4b: 0, 500, 1000, 1500 for ccc solid lesions)
- Axial BFFE

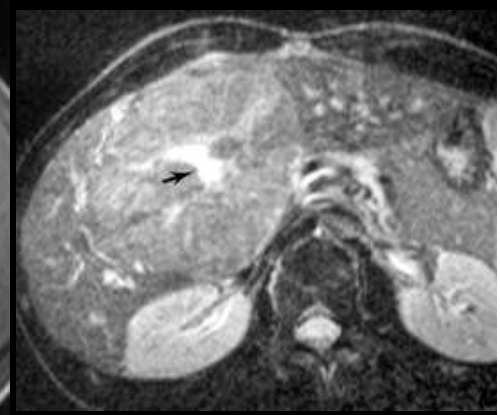
- T1W Axial (In Phase) aligned all protons = ↑ fat signal (fatty infiltration ↑ bright)
- T1W Axial (Out Phase) unaligned all protons = ↓ fat signal

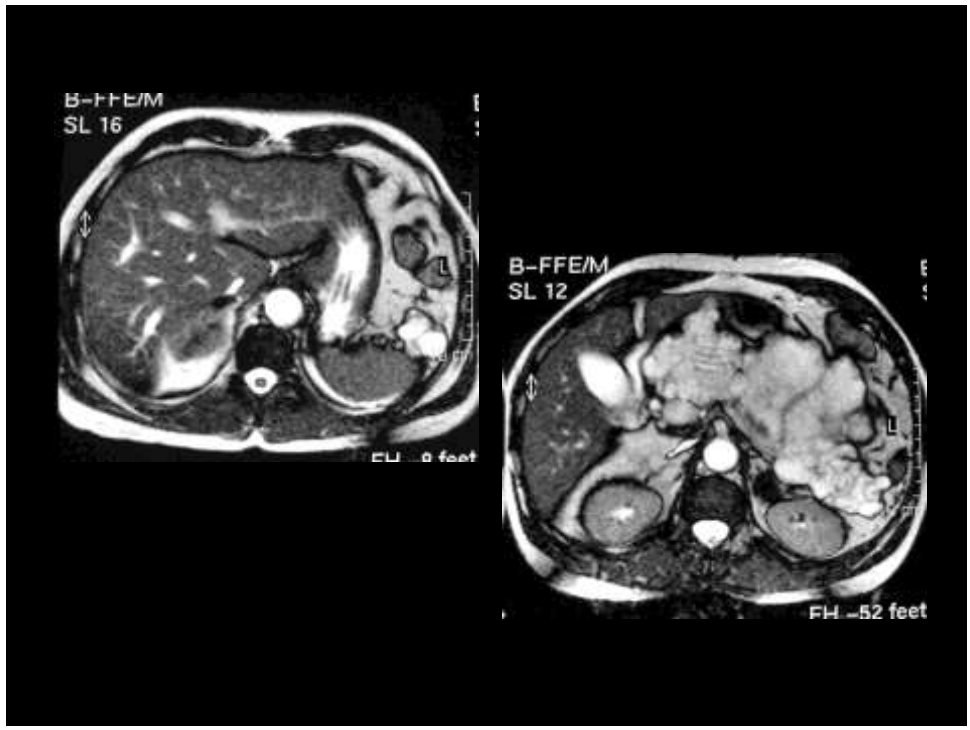
- Coronal BFFE (vessel sensitive sequence)

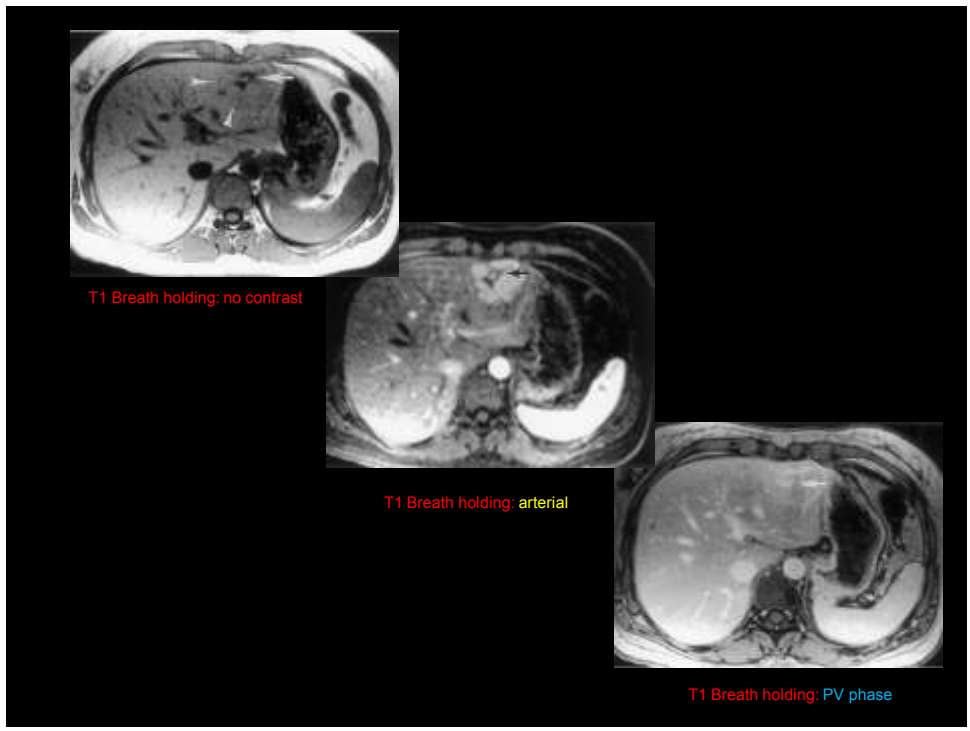
Post contrast: (Arterial / Porto-Venous / Delayed)
-T1 W Thrive axial post contrast SPIR
-T1 W Thrive coronal (breath hold)

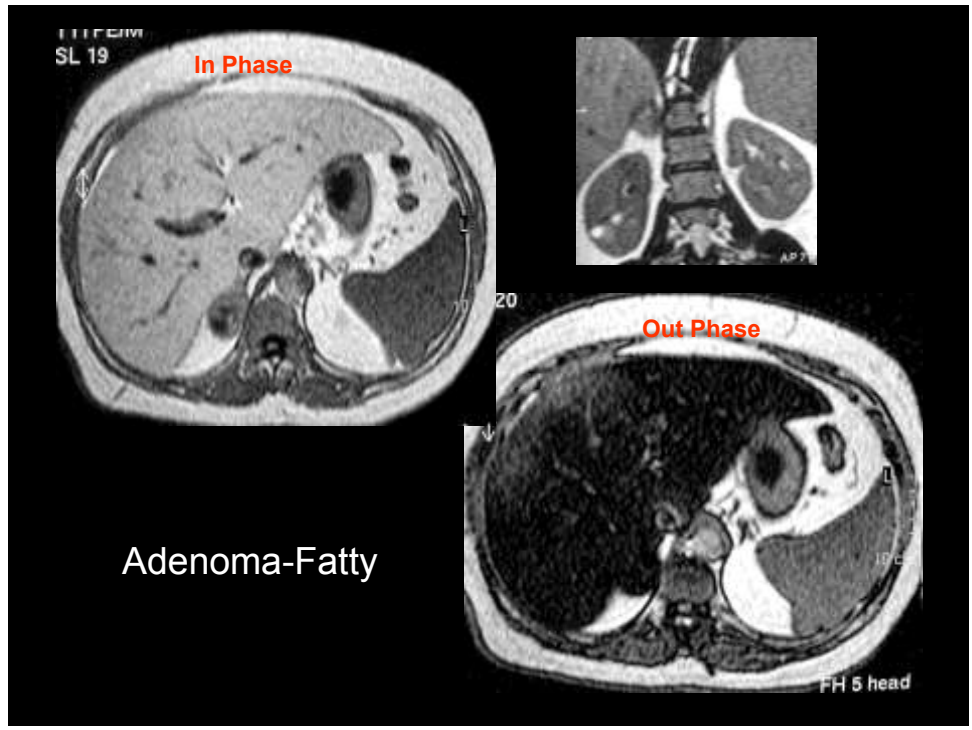


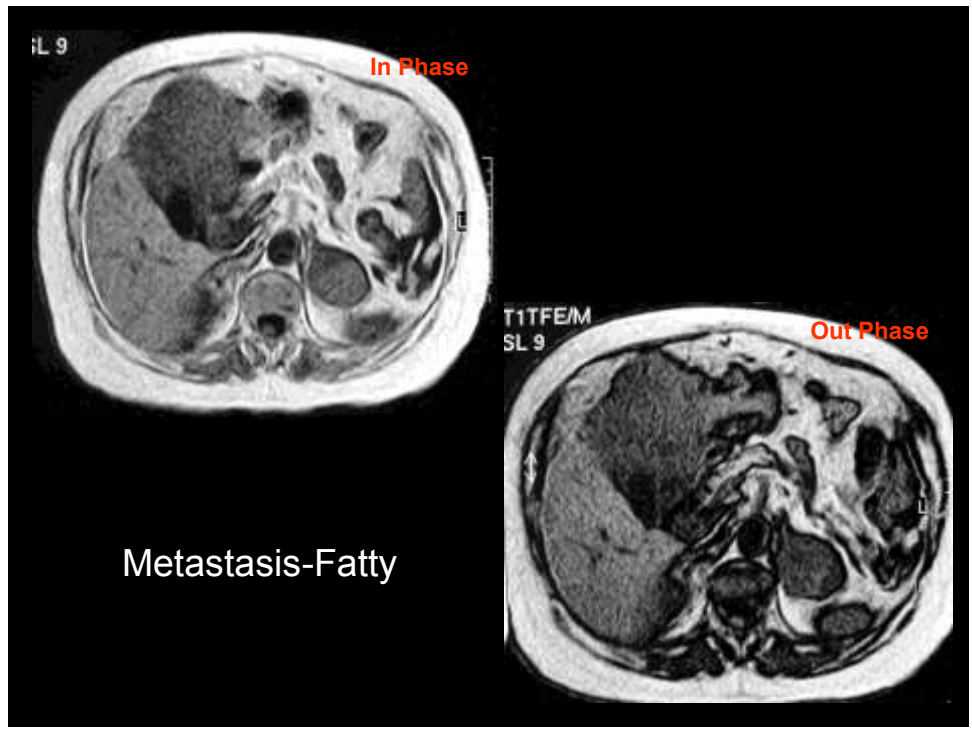
MRI Abdomen




B-FFE/M
SL 16
B-FFE/M
SL 12
FH -52 feet


T1 Breath holding: no contrast
T1 Breath holding: arterial
T1 Breath holding: PV phase


SL 19
In Phase
Out Phase
FH 5 head
Adenoma-Fatty


In Phase
T1TFE/M
SL 9
Out Phase
Metastasis-Fatty

MRI Pelvis -1 (Male soft tissue organs)

- T1W coronal (parallel to rectal axis)
- T2W coronal
- T1W axial
- T2W axial SPIR (⊥ rectal axis)
- T2W sagittal
- DWI (3b values: 0, 200, 800)

If suspicious tumor:
T1 W Thrive axial SPIR+C
T1 W sagittal / coronal SPIR+C

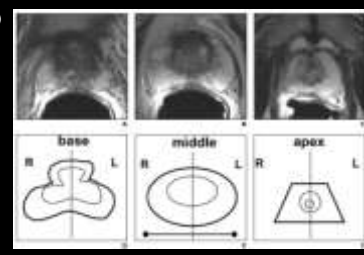
NB: rectal filling with gel for staging

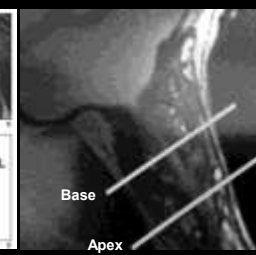
Indications:
- In Males:
  - Staging cancer bladder
  - Staging cancer prostate

MRI Pelvis –Prostate (Multiparametric prostate: 2-3 mm / 0 gap)

(PZ, TZ, CZ / TZ+CZ = central gland / base to UB, mid prostate, apex)

- T1W coronal (for post biopsy hge)
- T2W coronal
- T1W axial (post biopsy 6 wks)
- T2W axial
- T2W axial SPIR
- T2W sagittal
- DWI (3b values: 0, 1000, 2000)
- Small lesions: DTI of pelvis !

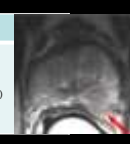


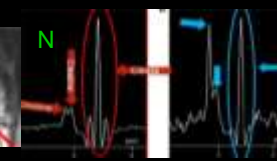


If suspicious tumor > 0.2 ml:
- Dynamic contrast-enhanced MTI (DCE-MRI): 7 transverse sections / 2 secs for 90-120 sec: **K trans**
- 3D Multivoxel 120 spectroscopy (MRS): Ch + Cr / Citrate

NB: must have a half filled bladder

Spectroscopy : Ch + Cr / Citrate		DWI: ADC value (? relative ADC)	
Normal	: 0.34	Low	: 1.2 – 1.4
Low	: 0.5 – 0.7	Interm.	: 1 – 1.1
Interm.	: 0.71 – 0.96	High G	: 0.8 – 1 (worst + extracapsular)
High	: 0.97 – 1.14		





Never to be used post hormonal therapy as altered results !!
Cho + Ct / Cit = aggressivity of tumor
Cho + Cr / Cit = for therapeutic effectiveness
Cho + Cr / Cit (TZ)= N= 0.63 / Malign = 0.93

Citrate is produced by PZ
Cho ↑ at periuretheral zone

MRI Prostate (Multiparametric prostate: 2-3 mm / 0 gap)

Manogram: T2 + MRS + ADC + K-trans (N / lesion

- High probability: +++
- Intermediate probability: ++
- Low probability: +

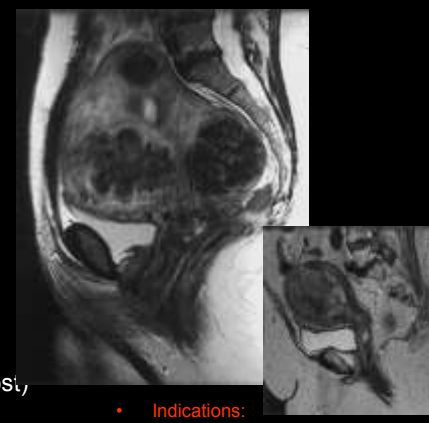
MRI Pelvis - 3 (Female soft tissue organs)

- T1W coronal
- T2W coronal oblique (parallel to uterus)
- T1W axial
- T2W axial oblique SPIR (⊥ uterine axis)
- T2W sagittal
- DWI (3b values: 0,1000)

+/- T2W-DWI axial abdomen
(for peritoneal reflections)

If suspicious tumor:
T1 W Thrive axial SPIR+C (1 pre + 4 post)
MRA pelvis: uterine embolisation protocol

NB: vaginal / rectal filling is imp if looking to pelvic fistulae
(+ HR 3D fistulogram)



- Indications:
  - Staging of cervical or uterine pathologies
  - Characterization of ovarian tumors

MRI Colonography

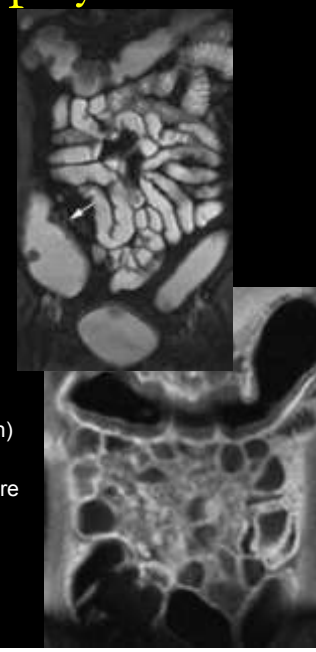
Pre test: anti-peristaltic measures
+ Enema 1.5 L light Ba/water + mannitol

- T2W axial
- T1W coronal (covering the whole bowel)
- T2W coronal
- DWI coronal (3b values: 60, 400, 800)
- T1W axial
- T2W sagittal

If suspicious tumor:
- T1W+C axial / coronal fat suppression
- Coronal dynamic THRIVE (1 pre, 5 post – 20 sec each)

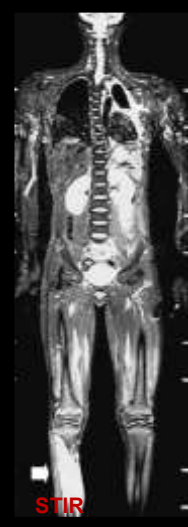
MRI enterography: 1.5 L light Ba/water + mannitol 45 min before exam orally.

MRI enteroclysis: 1.5 L light Ba/water + mannitol via naso-jejuneal catheter

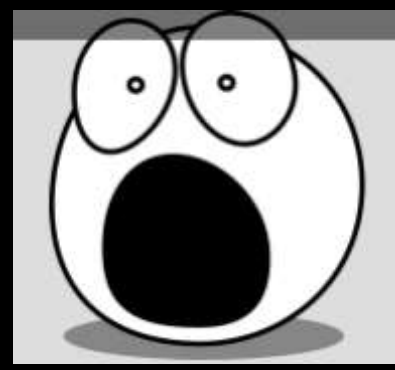


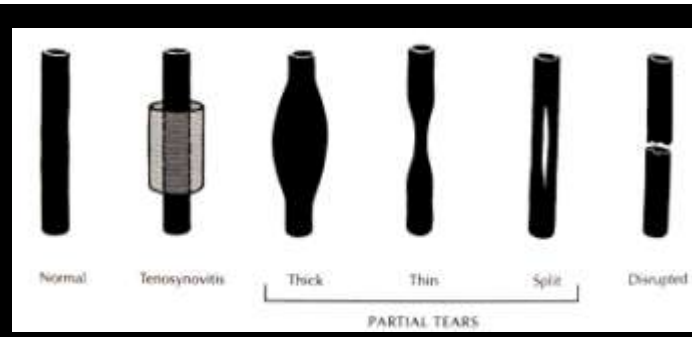
Whole body MRI

Wb MRI: includes coronal DWIBs, STIR, T1W + Axial T2W / DW (b0, 500, 1000)



Msk
Anatomy & Protocols





Msk Rule 1: Thick tendon + no fluid = chronic injury e.g. T. Achilles

Msk Rule 2: Intermediate T2 signal = degeneration / tendinitis
High signal in a tendon on T2 = partial tear

Msk Rule 3: 2 ligaments in body can split: peroneus brevis / biceps tendon

Msk Rule 4: Muscular injuries:

Grade I:	DOMS.oreness:	low T1 & high T2 (edema)
Grade II:	Partial tear:	High T1 & T2 (blood +focal defect)
Grade III:	Complete tear:	low T1 & T2 (loss of ms strenght)

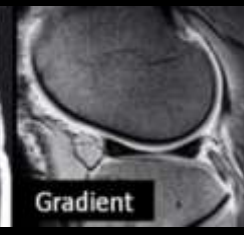
Msk Rule 5: Tenosynovitis / stenosing T / Chronic tenosynovitis

Fat suppression (Msk)

T2 Fat saturation	T2 Fat saturation	T1 / PD Fat saturation	Dixon
- **S**pectral **P**resaturation with **I**nversion **R**ecovery - TSE either T2 or T1 - ETL 10 + angle 90 - Inhomogenous fat suppression after Gd -Takes > time = better quality - For big structures	-**S**hort **TI** **I**nversion **R**ecovery - T2 FSE + Fat supp - Best =homogenous fat suppression after Gd - For BM + soft tissue - For small structures	**T1 Fat saturation** - Only on MRI > 1T - Used after Gd-DPTA / Gd-Arthro - Inhomogenous fat suppression - Best for seeing cartilage - DD fat from hemorrhage (w will be brighter !!)	-**2-point Dixon technique** 2 images: 1 with the fat and water spins in-phase and the other with them out-of-phase. Then images added together = fat suppressed image

Bone Marrow

T1 white, T2 Intermediate
Gradient > black, STIR: completely black



Tissue	T1	T2	T2*	STIR
Bone marrow	High	low↓	Low ↓↓	Low ↓↓↓
Fat	high	low↓	Low ↓↓	Low ↓↓
Cortex	Low	Low	Low	Low
Ligaments Tendons	Low	Low	Low	Low
Muscles	Intermediate	Low	Low	Low

Why GRE T2* in MSK ?
1- Highlight fluid.
2- For cartilage, ligaments
3- For fibrocartilaginous structures

Ankle Joint MRI

MRI Ankle protocol: (FOV 8-12 cm)

-T1 W axials	(both ankles)
-T2 W axials	(both ankles)
- T1 W Sagittal	(on affected ankle)
- T2 W SPIR Sagittal	(on affected ankle)
-T1 W coronals	(both ankles)
-T2 W coronals	(both ankles)

Indications:

- Achilles'-tendon rupture
- Avascular necrosis of the talus
- Tenosynovitis, tumors, Infections….

MRI Ankle protocol:

Anterior compartment

Extensors: TA - EHL – EDL (rare)

Postero-medial c.

Flexors: TP - FHL - FDL

Deltoid ligament (coronal only)

Tarsal tunnel anatomy

Lateral compartment

Peroneus Longus = Peroneus Brevis

Tibio-fibular syndesmotic complex (Tibial L.)

Talo-fibular LCL (Talus L.)

Posterior compartment

Tendon Achilis (most imp / axial only)

Anatomy-based Imaging issues

Imaging

Achillus tendon = biggest / no sheath

Lateral syndesmotic complex

- Ant tibio-fibular lig
- Post tibio-fibular lig (ptf)
- Inf. Transverse lig (d ptf)
- Interosseus lig

Fibula : lateral: Peroneus L+B

1-MR Ankle anatomy: axial (tibial level)

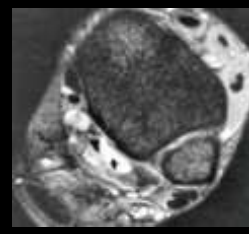
Anatomy-based Imaging issues

Imaging

Lateral collateral lig
- Ant **talo**-fibular lig (most imp.)
- Post **talo**-fibular lig (PCL like)
- Calcaneo-fibular lig

Postero-medial compartment
- TP
- FDL- FHL
- Post tibial NAV
- Abductor hallucis
- Quadretus plantaris

2-MR Ankle anatomy: axial (talus level)



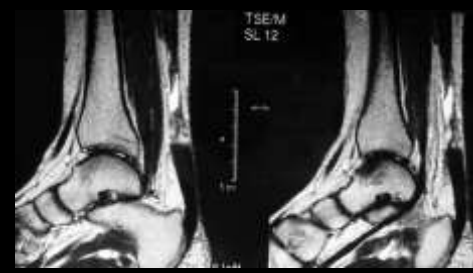
Tarsal-tunnel
At level of : sustentaculum tali

Anatomy-based Imaging issues

Imaging

For:
- Talus (avasc. N)
- Sinus tarsi
  - Cervical lig
  - Interosseus lig
  - Fat + Nerves
- Plantar fascia = 4 mm

3-MR ankle anatomy: sagittal

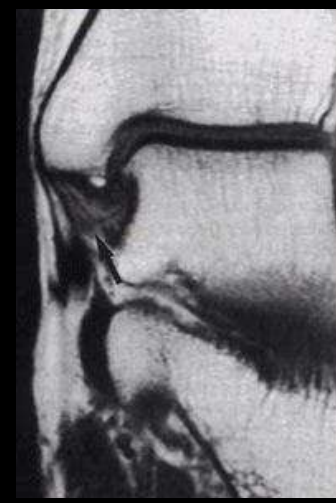


Anatomy-based Imaging issues

Imaging

Medial Deltoid lig
- Tibio-talar lig
- Others…..

4-MR ankle anatomy: coronal



MR Shoulder protocol:

-T1 W axials
-T2* W axials

-T1 W oblique coronals
-T2 W oblique coronals
-T2W SPIR oblique coronals

-T2 W oblique sagittals

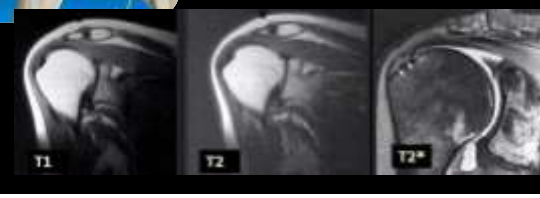
In inflammation, tumors, post contrast:
-T1 W oblique coronals + C (SPIR)
-T1 W axials + C (SPIR)

Anatomy-based Imaging issues

Imaging

1-MR Shoulder anatomy: coronal

Biceps Labrum complex
Inferior Labrum complex



For:

- Supraspinatus
- Infraspinatus
- Superior labrum + BT
- Inferior labrum + IGHL
- A/C osteoarthritis
- Subacromial bursae

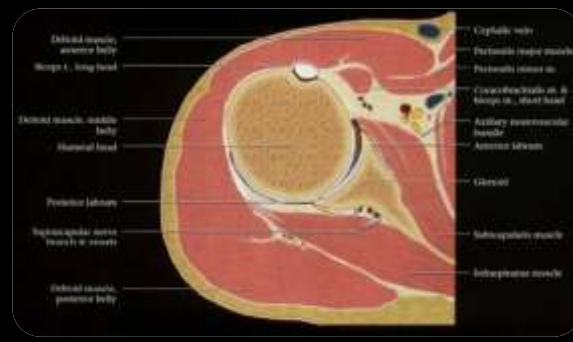
Anatomy-based Imaging issues

Imaging

2-MR Shoulder anatomy: axial

For:

- Anterior / Post labrum
- Biceps tendon
- MGHL
- Humeral head
- Subacromial bursae

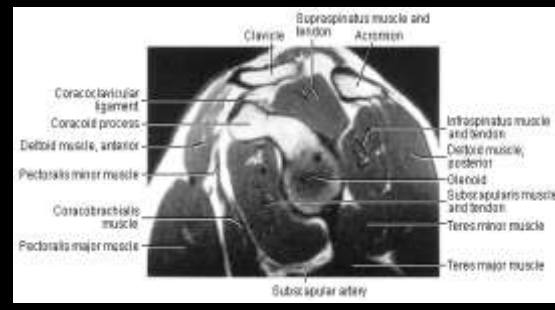


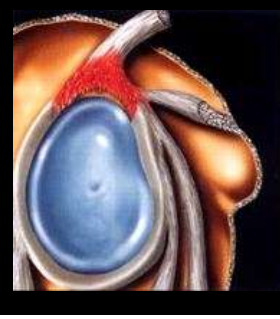
Anatomy-based Imaging issues

Imaging

- Supraspinatus & other
- IGHL
- Rotator interval
- Acromial shape
- Subcoracoid bursae

3-MR Shoulder anatomy: sagittal



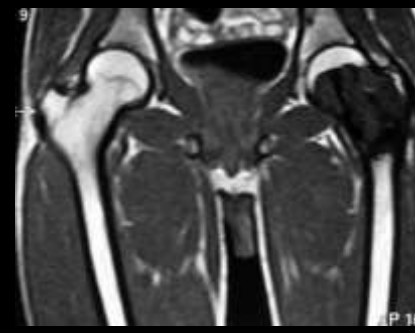


Hip Joint MRI

MRI Hip

-T1 W axials
-T2 W axials
-T1 W coronals
-T2 W coronals

-T2*W coronals
- T2 W coronals SPIR



If inflammation, tumors, etc… inject contrast:
-T1 W axials SPIR + C
-T1 W coronal SPIR + C

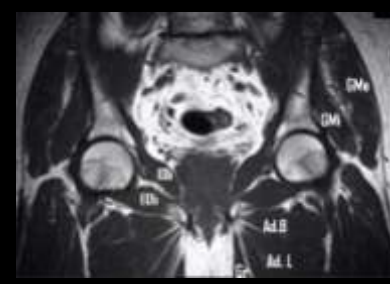
Indications:
- Avascular necrosis of femoral head
- Labial tears
- Infections….tumors…..

Anatomy-based Imaging issues

Imaging

- Head of femur
- Acetabulum (ilium-ischium-pubis)
- 95% of F head intraA
- Sup & inferior labri
- Sacroliac joint (sacral & iliac surfaces)
- Pelvic stuctures

1-MR Hip anatomy: coronal



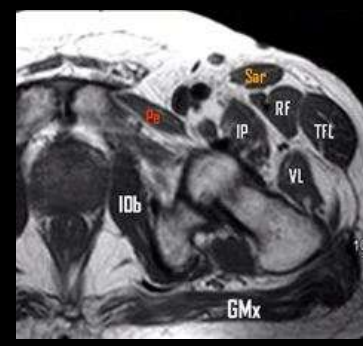
Anatomy-based Imaging issues

Imaging

For:

- Ms Iliopsoas ms & bursae (biggest in body)
- Sciatic nerve
- Pelvic stuctures

2-MR hip anatomy: axial



Knee Joint MRI

MR Knee protocol:

- Sag T2
- Sag PD (menisceal window)
- Cor T1
- Cor T2 SPIR
- Axial T2 SPIR

Indications:

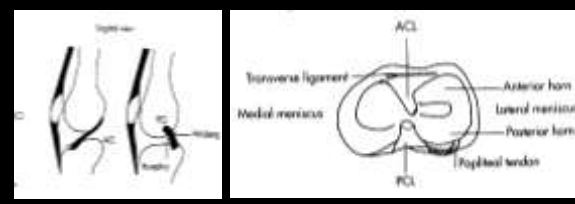
- Menisci, cruciate lig, in sport injuries
- Post-trauma
- Tumors, Infections….

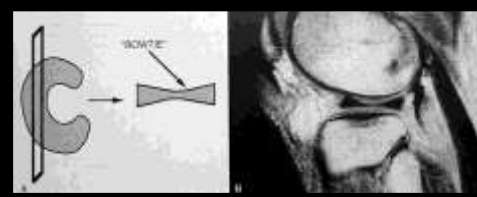
Anatomy-based Imaging issues

Imaging

- Meniscus (sup / inf articular surfaces – meniscocapsulat attachement)
- Body weight max on large & strong PHMM
- ACL – PCL (signal free)
- Tibial translocation >5mm

1-MR knee anatomy: sagittal

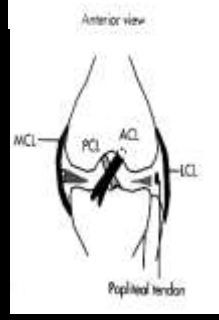




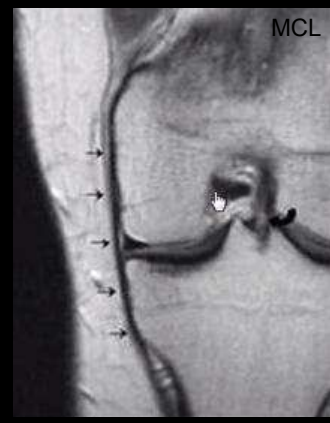
Anatomy-based Imaging issues

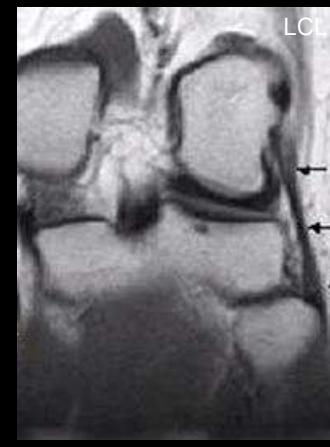
Imaging

- Long MCL 10 cm
- Short LCL 9 cm
- Biceps tendon
- Quadriceps tendon
- Bone contusion (STIR)



2-MR Knee anatomy: coronal



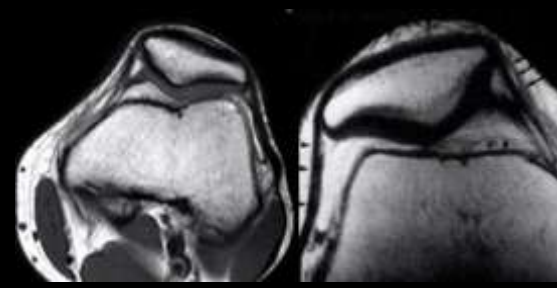


Anatomy-based Imaging issues

Imaging

- Patella
- Lat patellar retinaculum (1 fasc)
- Med patellar retinaculum (2 fascicles)
- Straight ACL & only horizontal portion of PCL

3-MR Knee anatomy: axial



Part IV
Cardiac / Msk Imaging
MRI

MRI Wrist protocol (FOV 8-12 cm)

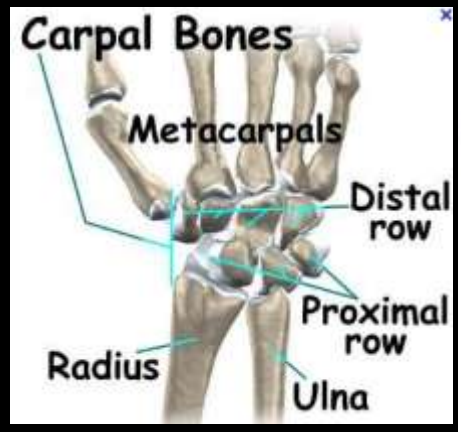
- Axial T1 (high resolution – each alone)
- Axial T2 (high resolution – each alone)

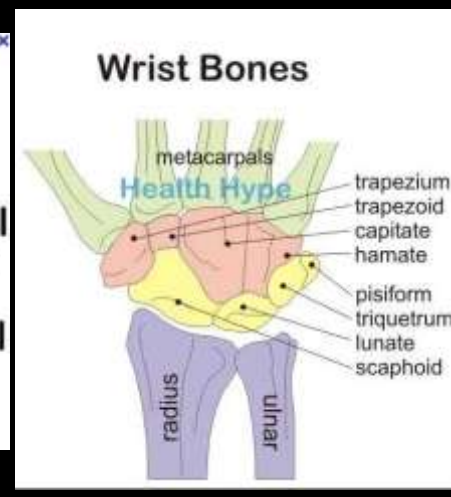
- Cor T2* (2 mm thickness)
- Cor T2 (2 mm thickness)
- Sagittal T1

Indications:

- Carpal tunnel $
- Avascular necrosis of scaphoid
- Rheumatoid arthritis
- Scapho-lunate & scapho-triquetral lig. wrist instability

Pure anatomy…





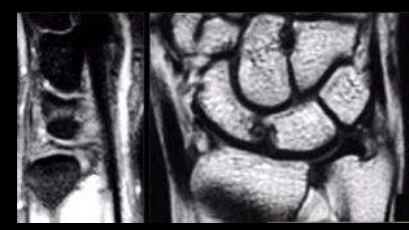
Anatomy-based Imaging issues

Imaging

For:

- TFCComplex
- AVN of any bone…
- Scapholunate & lunotriquetrial ligaments
- Ulnar variance (2mm)

1-MR wrist anatomy: coronal

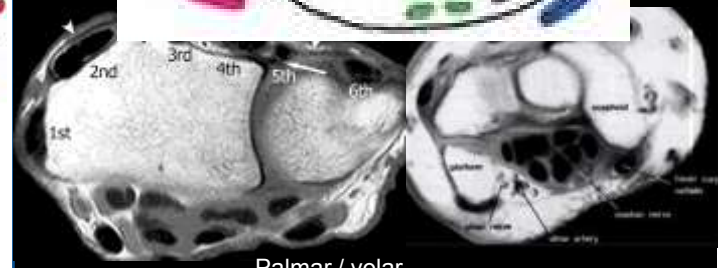


Anatomy-based Imaging issues

Imaging

For:
- Flexor of wrist
- Extensor of wrist / Lister's
- Carpal tunnel
- Assess DRUJ

2-MR wrist anatomy: axial



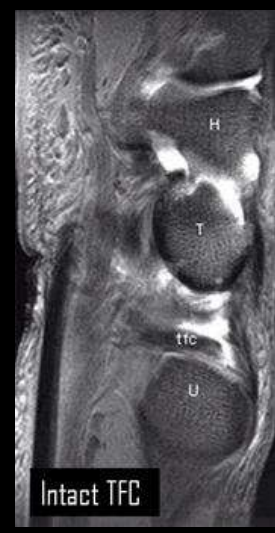
Palmar / volar

Anatomy-based Imaging issues

Imaging

For:
- Confirm TFCC status
- Tendon of fingers

3-MR wrist anatomy: sagittal

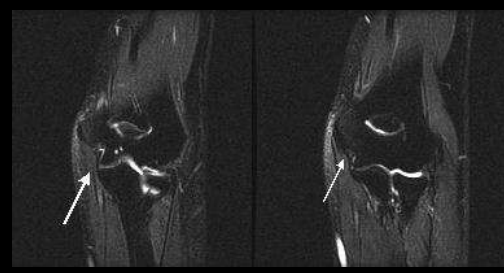


MR Elbow protocol:

- **Axial T2** (high resolution – each alone)
- **Sagittal T2**

- **Fat supp** (for cartilage)

- **Coronal T1** (2 mm thickness)
- **Coronal STIR** (2 mm thickness)



Anatomy-based Imaging issues

Imaging

For:
- Bone
- Muscles

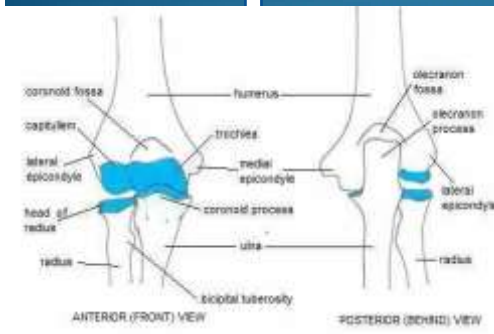
MR Elbow anatomy-1

Anterior compartment
- Biceps
- Brachialis + Median N

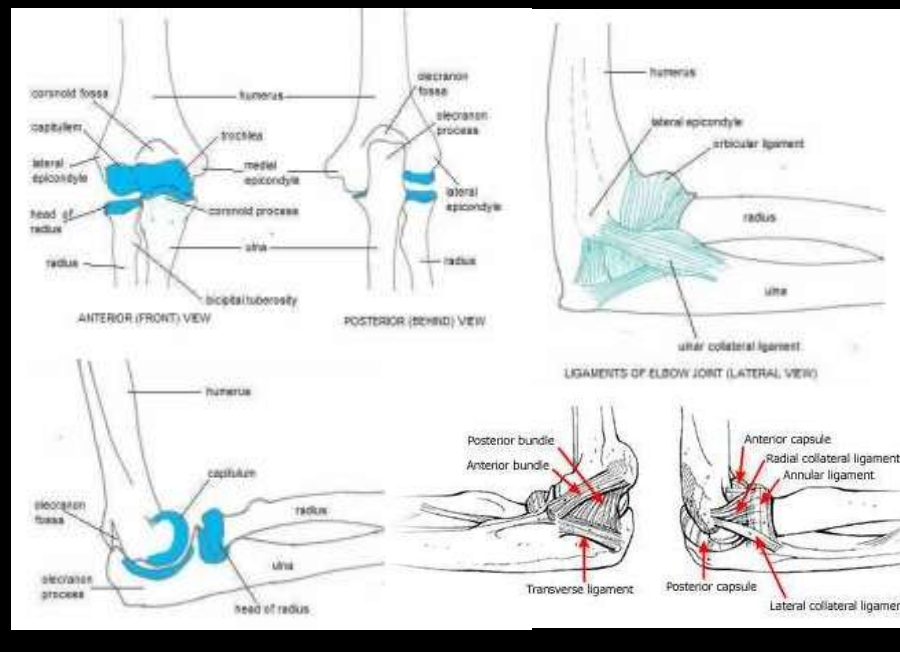
Lateral compartment
- Supinator
- Brachioradialis + R
- Ext. carpi radialis
- Ext. of H+ W

Medial compartment
- Pronator Teres
- Flexors of H + W

Posterior compartment
- Triceps
- Anconeus (small) + Ulnar N



MR Elbow anatomy-2



Anatomy-based Imaging issues

Imaging

For:

- Ant erior
  - Biceps (sup)
  - Brachialis (deep)
- Posterior
  - Triceps
  - Anconeus

1-MR Elbow anatomy: Sagittal

Anatomy-based Imaging issues

Imaging

For:

- Lateral / medial
- Common Ext .tendon
- LCL complex
- Common Flex origin (above)
- MCL (below)

2-MR Elbow anatomy: Coronal

Lateral compartment
- Ext. carpi radialis
- Supinator
- Brachioradialis
- Common Ext. of H+ W

Medial compartment
- Pronator Teres
- Common Flexors of H + W

MRI of the elbow, T1, coronal cut. Image 6

1 Ulna 2 Radial head 3 Lateral epicondyle 4 Extensor carpi radialis longus muscle 5 Olecranon fossa 6 Medial epicondyle 6a Common flexor tendon 7 Triceps muscle (lateral head) 8 Humerus 9 Triceps muscle (Medial head) 10 Flexor digitorum superficialis muscle 11 Supinator muscle 12 Extensor digitorum muscle

Anatomy-based Imaging issues

Imaging

3-MR Elbow anatomy: axial

Anterior: B+B (Ar + V i+ M nerve in between)
Posterior: T+A + Ulnar N (med.epicondyle)

Anterior compartment
- Biceps
- Brachialis

Lateral compartment
- Ext. carpi radialis
- Supinator
- Brachioradialis
- Ext. of H+ W

Medial compartment
- Pronator Teres
- Flexors of H + W

Posterior compartment
- Triceps
- Anconeus

MRI of the elbow, T1, axial cut.

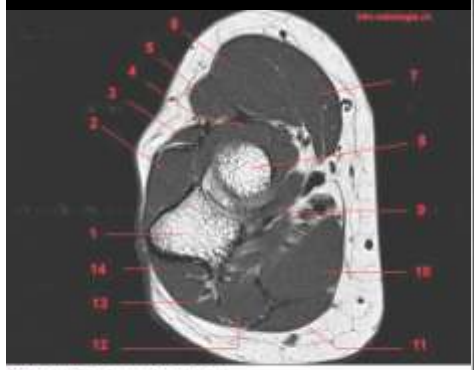
1 Humerus 2 Ulna 3 Anconeus muscle 4 Extensor digitorum muscle 5 Extensor carpi radialis longus muscle 6 Brachioradialis muscle 7 Brachialis muscle 8 Pronator teres muscle

Anatomy-based Imaging issues

Imaging

3-MR Elbow anatomy: axial

Anterior: B+B (Ar + V i+ M nerve in between)
Posterior: T+A + Ulnar N (med.epicondyle)
Radial N (below brachioradialis ms)



MRI of the elbow, T1, axial cut, image 4

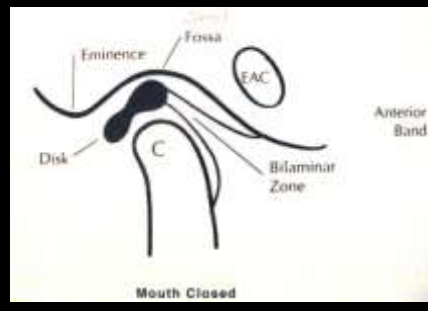
MRI of the elbow, T1, axial cut, image 14

TMJ Joint MRI

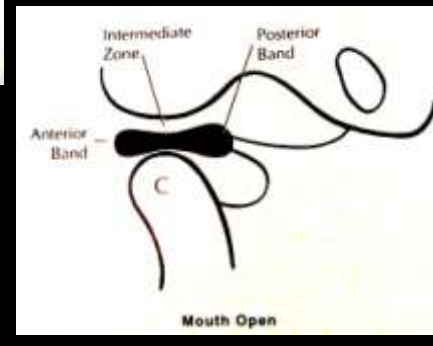
MR TMJ protocol:

- Sag T1 (open & closed)
- Sag T2 (open & closed)
- Cor T1 (open & closed)
- Cine (Dynamic)

Closed mouth



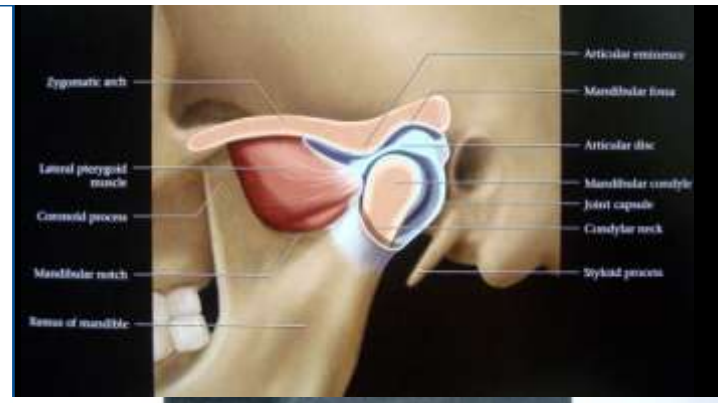
Mouth open

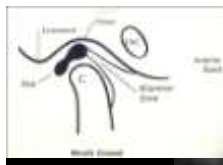


Anatomy-based Imaging issues

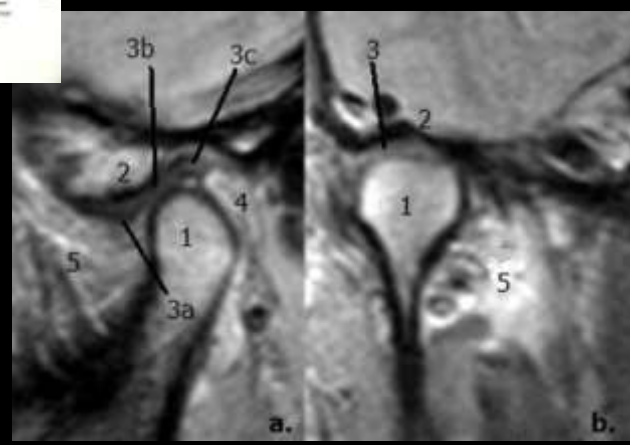
Imaging pitfall

i. TMJ





Closed mouth

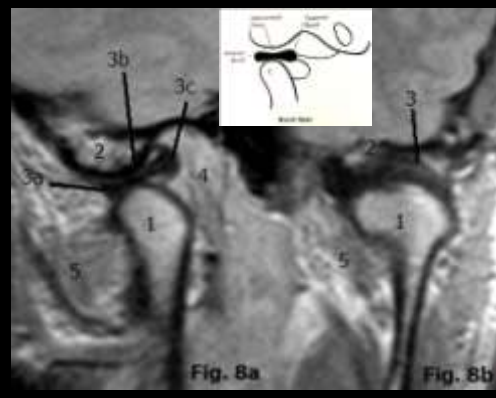


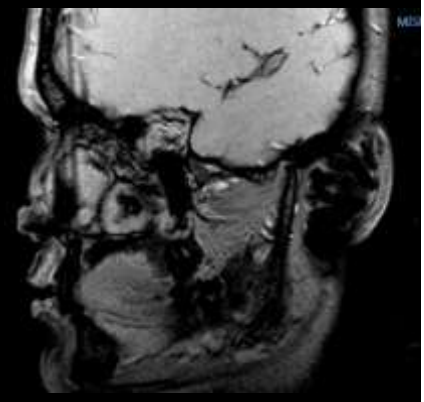
Sagittal (closed) Coronal (closed)

1 Mandibular head
2 Articular fossa
3 Disk (*3a*, anterior band; *3b*, intermediate zone; *3c*, posterior band)
4 Bilaminar zone
5 Lateral pterygoid muscle

Open mouth

Sagittal (Open) Coronal (Open)

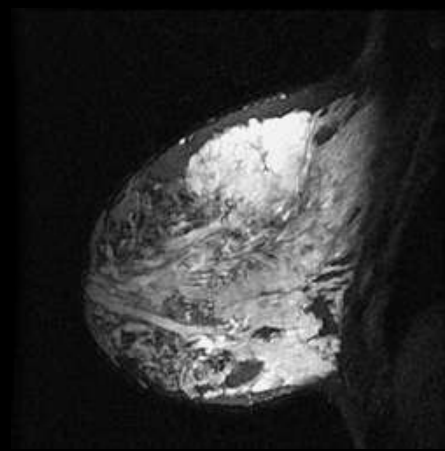




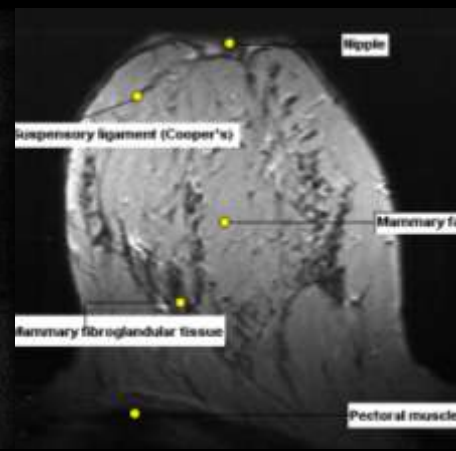
Note the bow-tie shape of the disk in the sagittal projection.

1 Mandibular head
2 Articular eminence
3 Disk (3a, anterior band; 3b, intermediate zone; 3c, posterior band)
4 Bilaminar zone
5 Lateral pterygoid muscle

Breast MRI



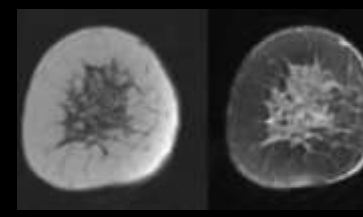
Non contrast MRI breast sagittal projection of lactating breast



Non-contrast MRI breast axial projection of normal non lactating breast

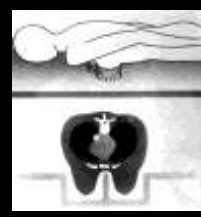
Breast Protocol

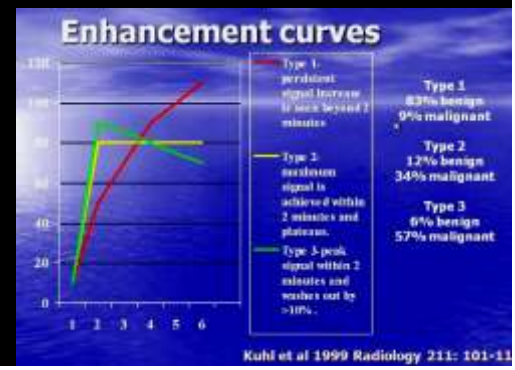
- T1 W axials (3-4 mm/gab 0)
- STIR axials (3-4 mm/gab 0)
- T2 W axials (3-4 mm/gab 0)
- DWI (b=0, 200, 800)



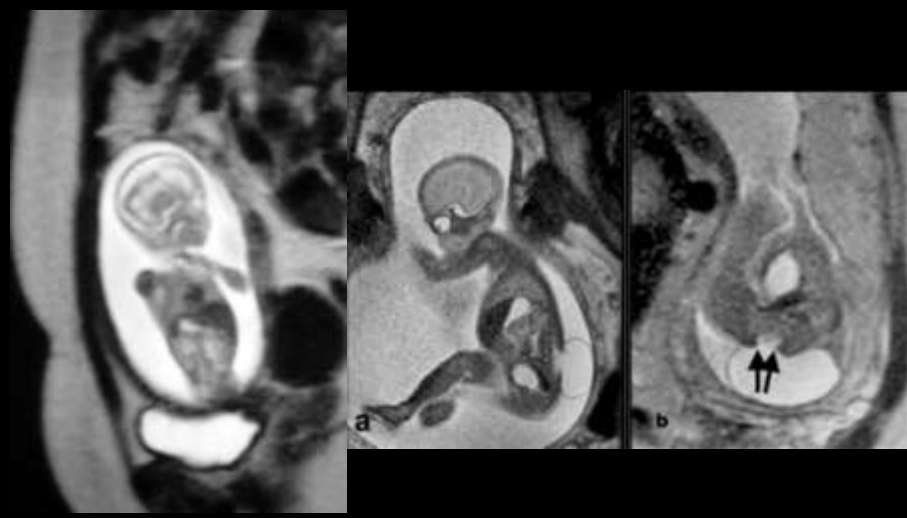
Injected I.V. contrast:

- Dynamic T1 W+C (Pre and During injection at 2.5m-5m-7.5m-1.0m - **subtraction from T1 W**)
- Delayed T1W+C (axial / Sag)
- MR Spectro: SV 270

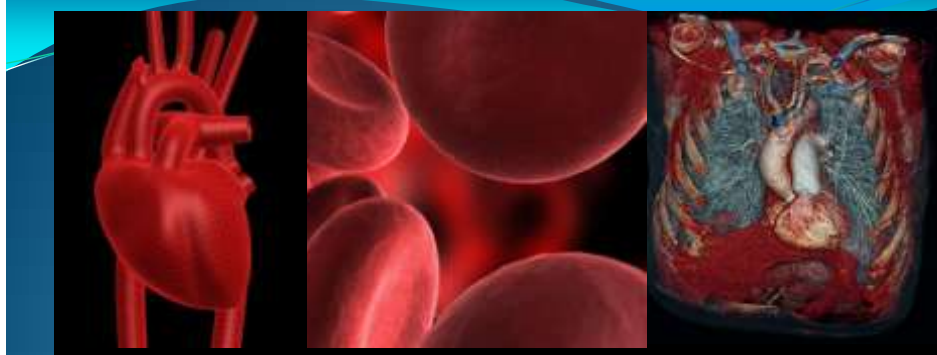




MRI Fetography



Part IV
Cardiac Imaging MRI



Cardiac anatomy imaging in 2012-2013

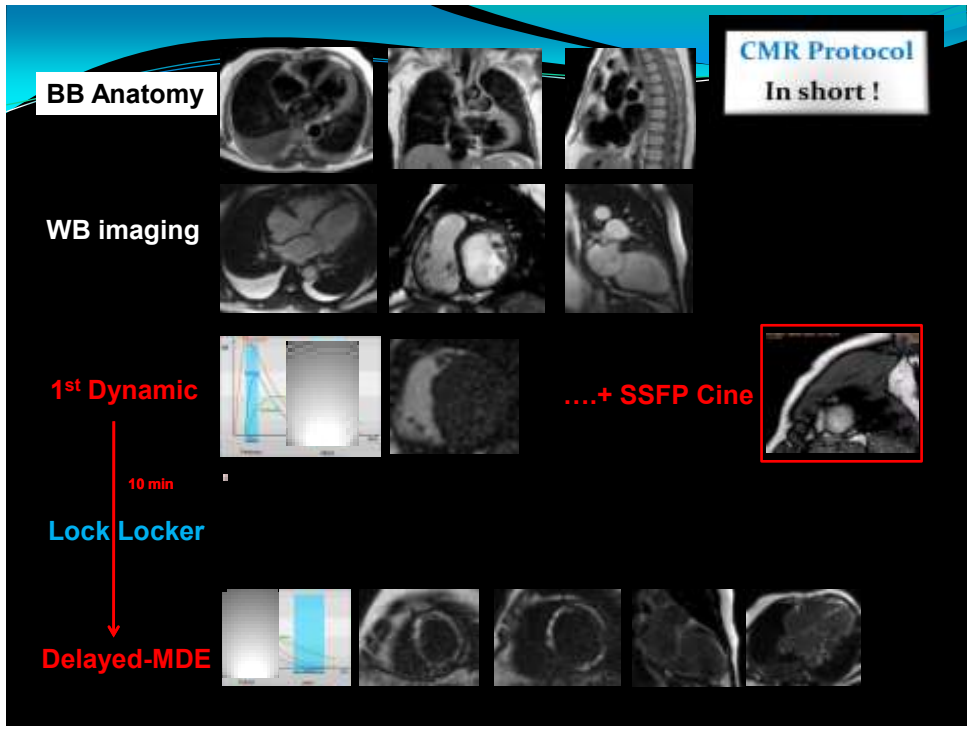
Coronary MDCT

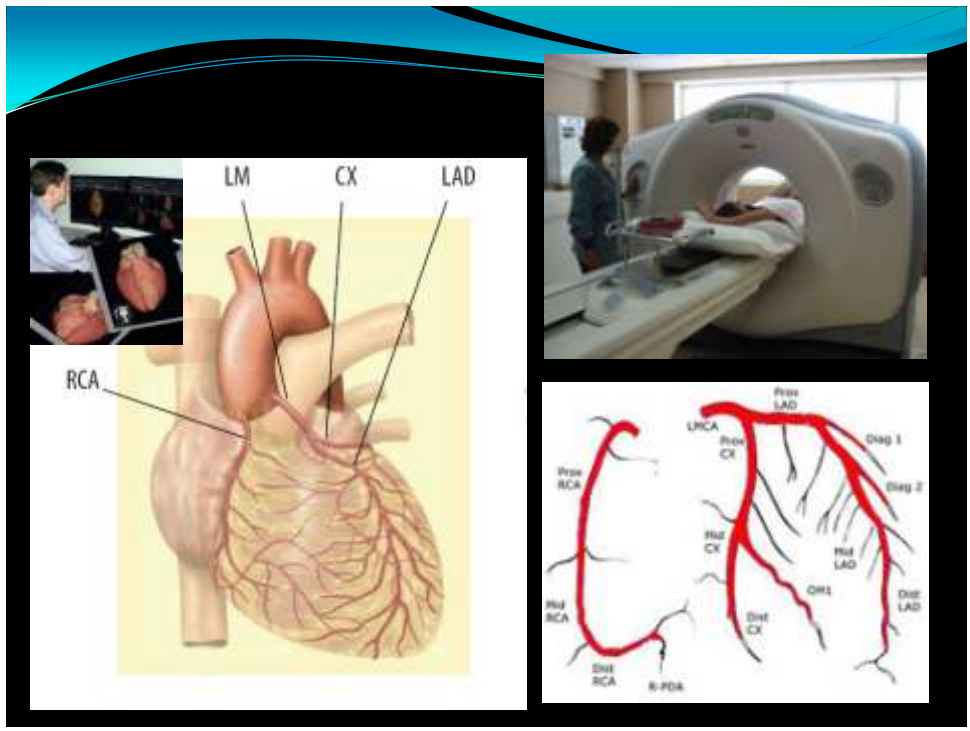
Cardiac MRI

Cardiovascular Magnetic Resonance (CMR)

Advantages:

1. Fast, multiplanar, high-spatial resolution
2. Reproducible tech to monitor follow up
3. Determine both LV & RV morphology & Fnc
4. Distinguish different types of cardiomyopathies
5. Detect myocardial: edema /iron / fat & fibrosis
6. Diff. DCM from cardiac dilatation d.t. CAD
7. High blood-myocardial tissue contrast (even in HF)
8. True 3D assessment, no blind spots, no problems in acoustic windows


CMR Protocol
In short !
BB Anatomy
WB imaging
1st Dynamic
10 min
Lock Locker
Delayed-MDE
....+ SSFP Cine


LM
CX
LAD
RCA

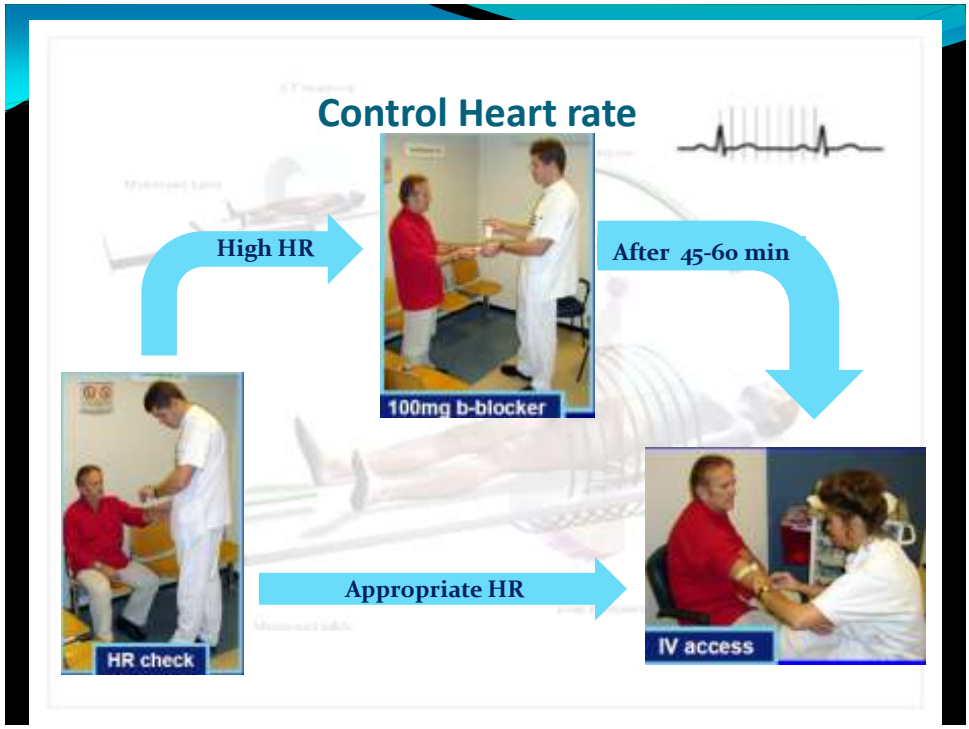
CTA coronary Pre-procedure Instructions

At home:

- NPO except medication 4 hours prior to the scheduled exam time
- No caffeine for 24 hours prior to the exam
- Metoprolol 100 mg p.o. 1 hour prior to exam (unless already beta blocked)
- No Viagra™, Cialis™, Levitra™ for 7 days prior

On CT machine

- Reassurance of the patient and explain the whole process.
- Mild oral sedation with diazepam (5 mg) in anxious individuals.
- Previous acute or chronic renal failure gadolinium compounds used as an alternative.
- A stable venous line, 18-to-20 gauge canula antecubital vein.
- Testing of the ability of the patient for sustaining a breath-hold long enough for the purposes of the examination.
- Empty bladder before scan

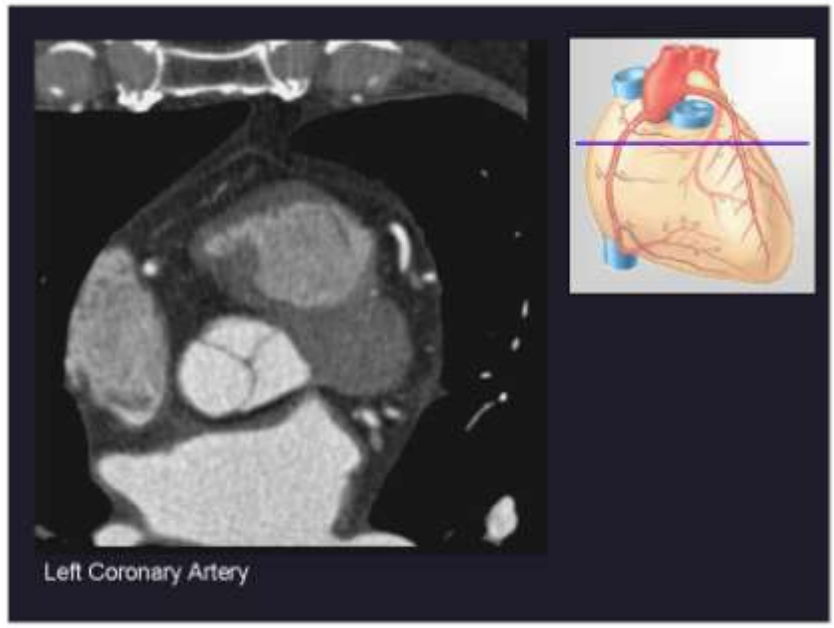


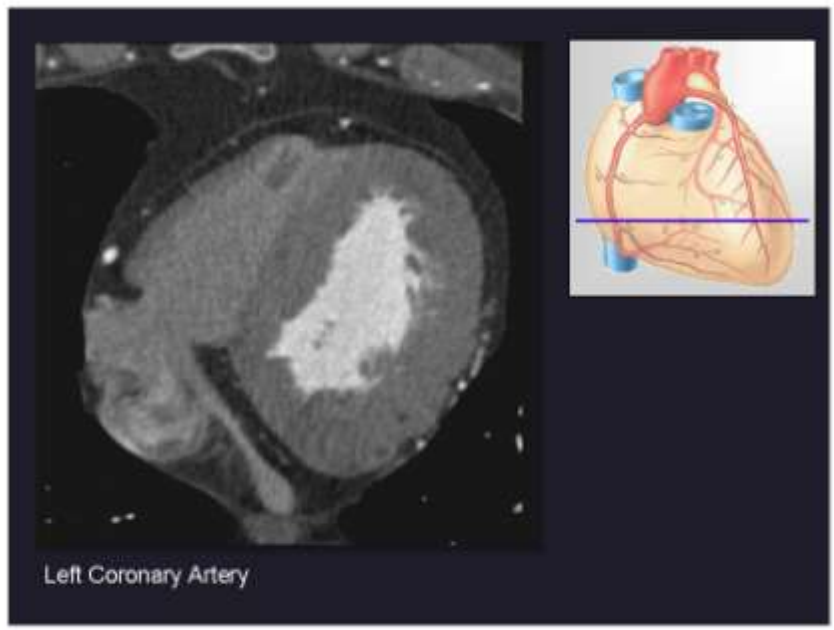

Instructions
ECG-leads
Breath hold / HR check
Injector connect


Left Coronary Artery

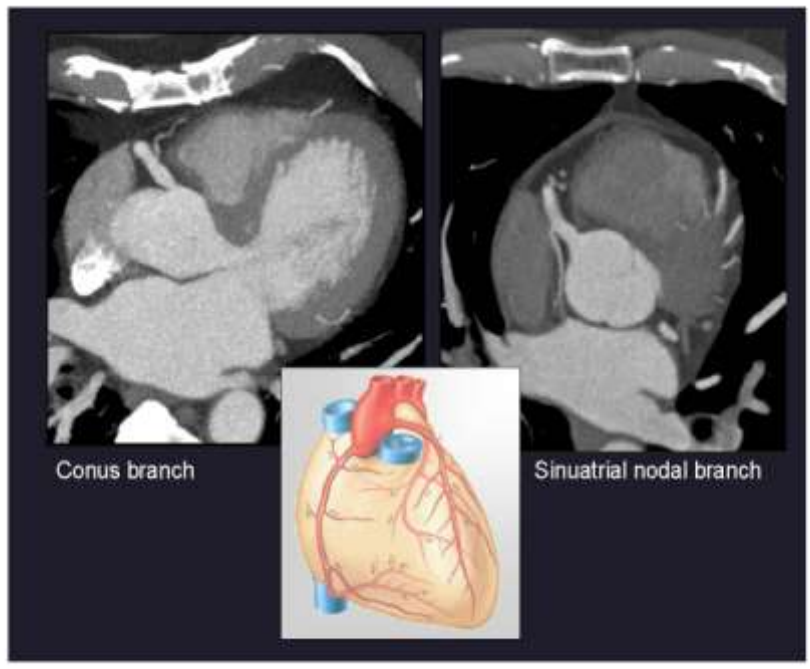

Left Coronary Artery

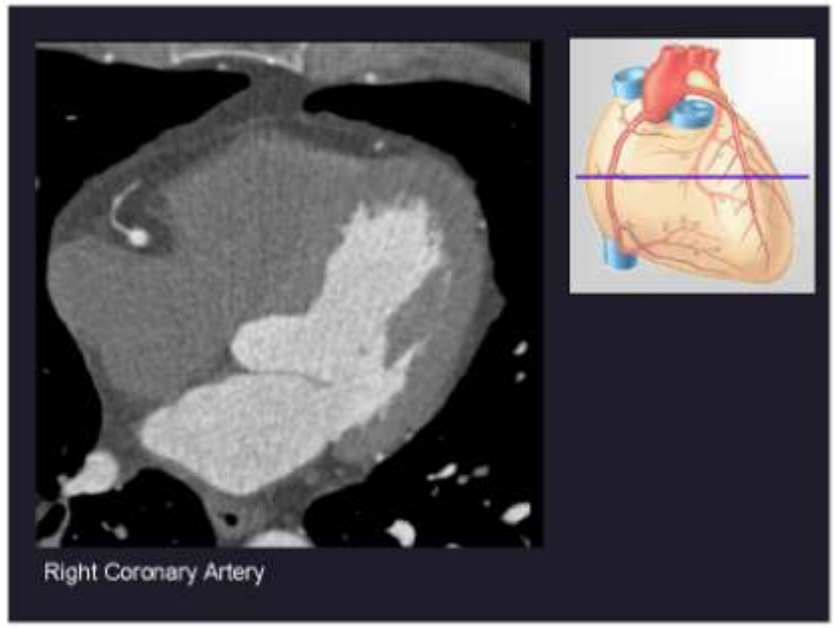

Left Coronary Artery


Left Coronary Artery

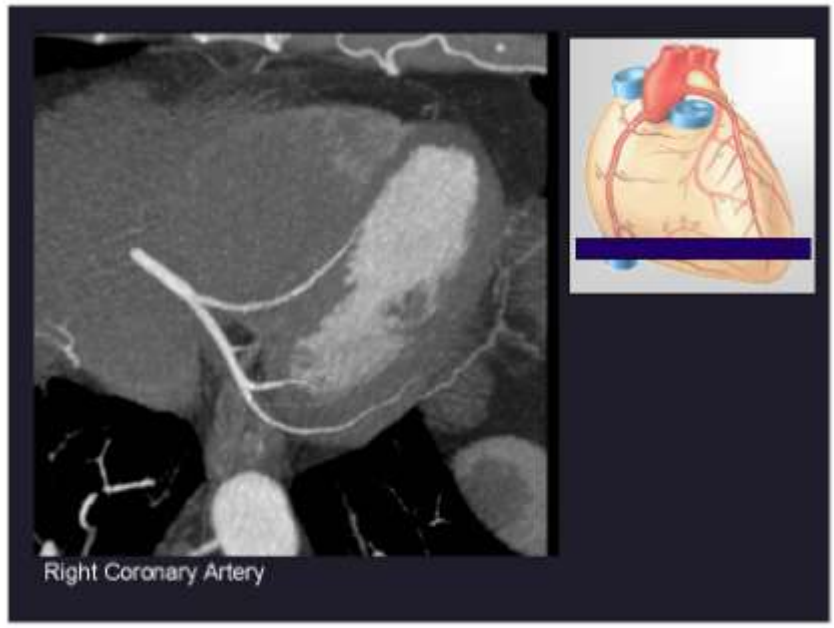

Left Coronary Artery


Right Coronary Artery


Conus branch
Sinuatrial nodal branch

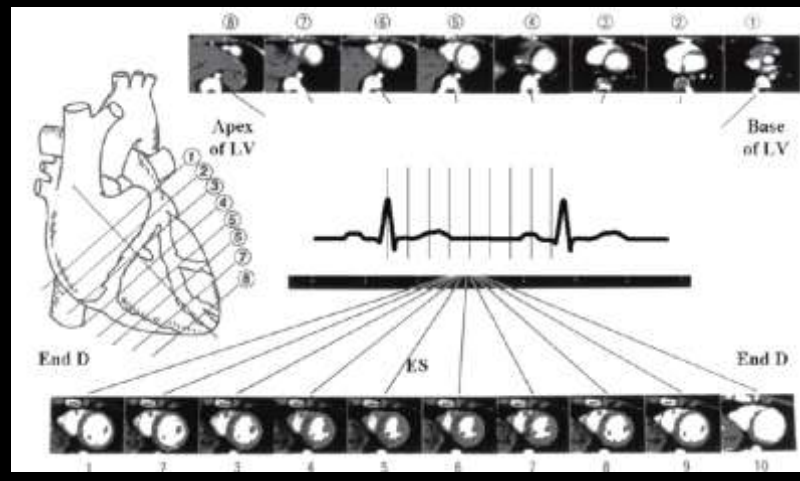

Right Coronary Artery

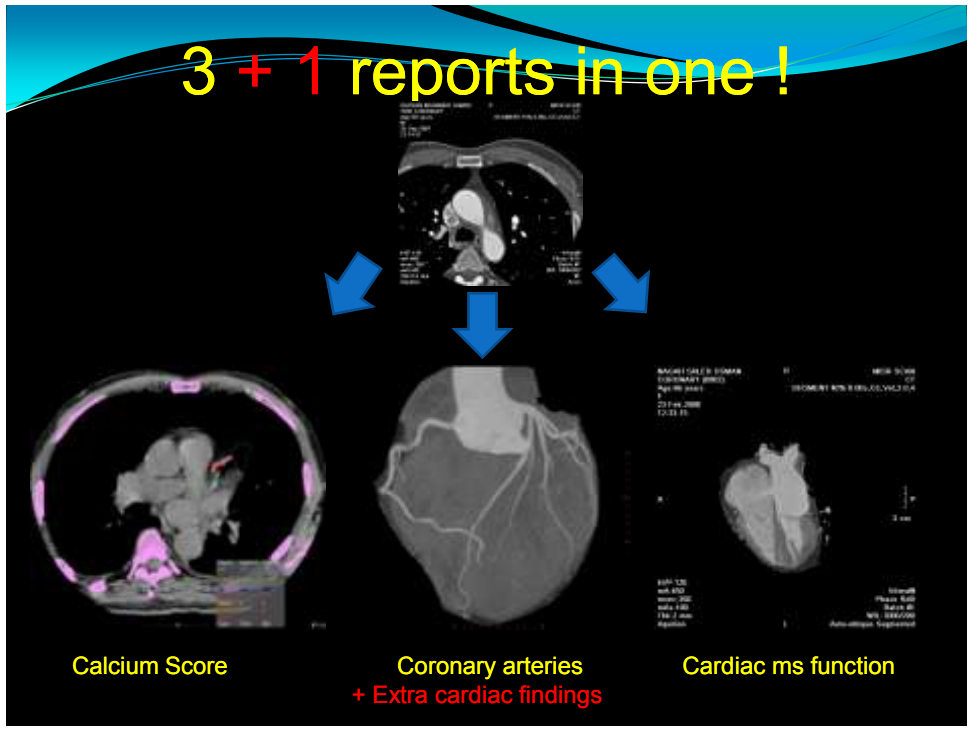

Right Coronary Artery



LV Function Assessment

Left ventricular volume measurements by MDCT are based on short-axis image reformations. At the mid ventricular level, a single image is reconstructed every 5% or 10% of the R-R interval to obtain both a diastolic and systolic phases



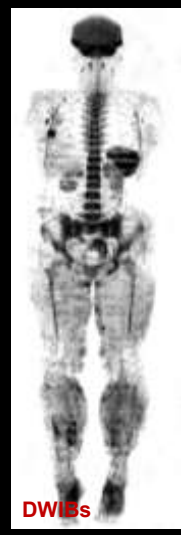


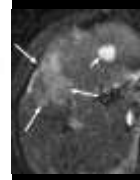
Part IV

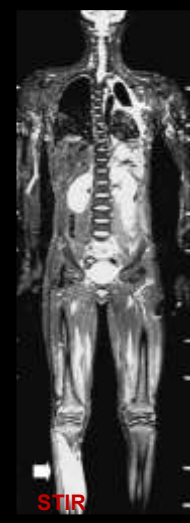
PET / MRI ?

Whole body MRI

Wb MRI: includes coronal DWIBs, STIR, T1W + Axial T2W / DW (b0, 500, 1000)

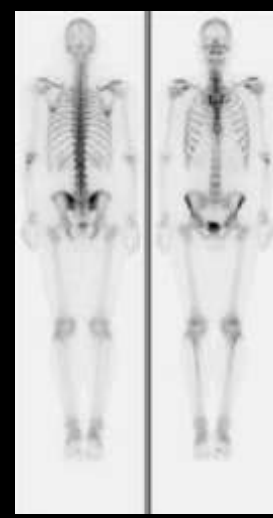






Bone Scan vs Wb-MRI

http://www.xrayrisk.com/calculator/calculator.php



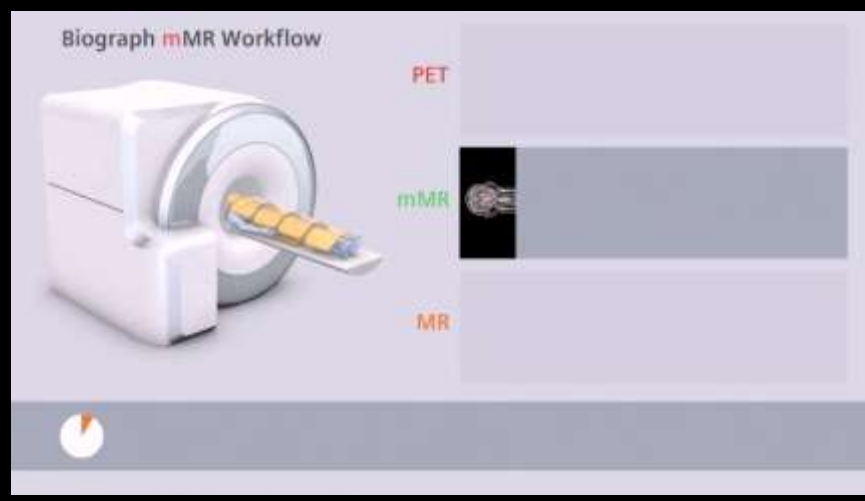
6.3 mSv !
Osseus Mets only
+ worldwide shortage of 99mTc

0 mSv !!!
Safe for pregnancy
Safe follow up !!

PET-CT vs Wb-MRI (2)

PET	PET-CT	Wb-MRI
Time / exam: 60 min	45-90 min	45-50 min
Long time of examination less comfortable	Long time of pre-examination preparation	Moderate time of examination more comfortable
Unsafe for pregnancy and children: **20 mSv** **(Yearly permissible dose = 5 mSv!!)**	Unsafe for pregnancy and children: **20-25 mSv**	safe for pregnancy and children **Safe follow up !!**
Weak in brain, urinary system	**Weak in** brain, urinary system	**Often non-diagnostic in** mediastinum, lung, LN, spleen
Fasting Pt. with good control for diabetic patients	Fasting Pt. with good control for diabetic patients	Fasting only if going to take Gd-DTPA
Not commonly available due to highly expensive and rare cyclotron	Not commonly available due to highly expensive and rare cyclotron **(5 cases/day !!)**	More Available
Expensive	Most expensive	Least expensive
Mets detection sensitivity 85%	Mets sensitivity 91%	Mets. sensitivity **93%**
LN sensitivity 91%	Highest LN sensitivity **95%** more accurate in the T.N staging	LN sensitivity 92%

Futur/Reality =Biograph mMR



Biograph mMR = 3T MRI+PET

Suggested web reading:

http:/www.imaios.com/en/

http://radiology.rsna.org/

http://www.radiologyassistant.nl/en/

Thank you

Ahmed Samir IBRAHIM, MD
asibrahima@gmail.com